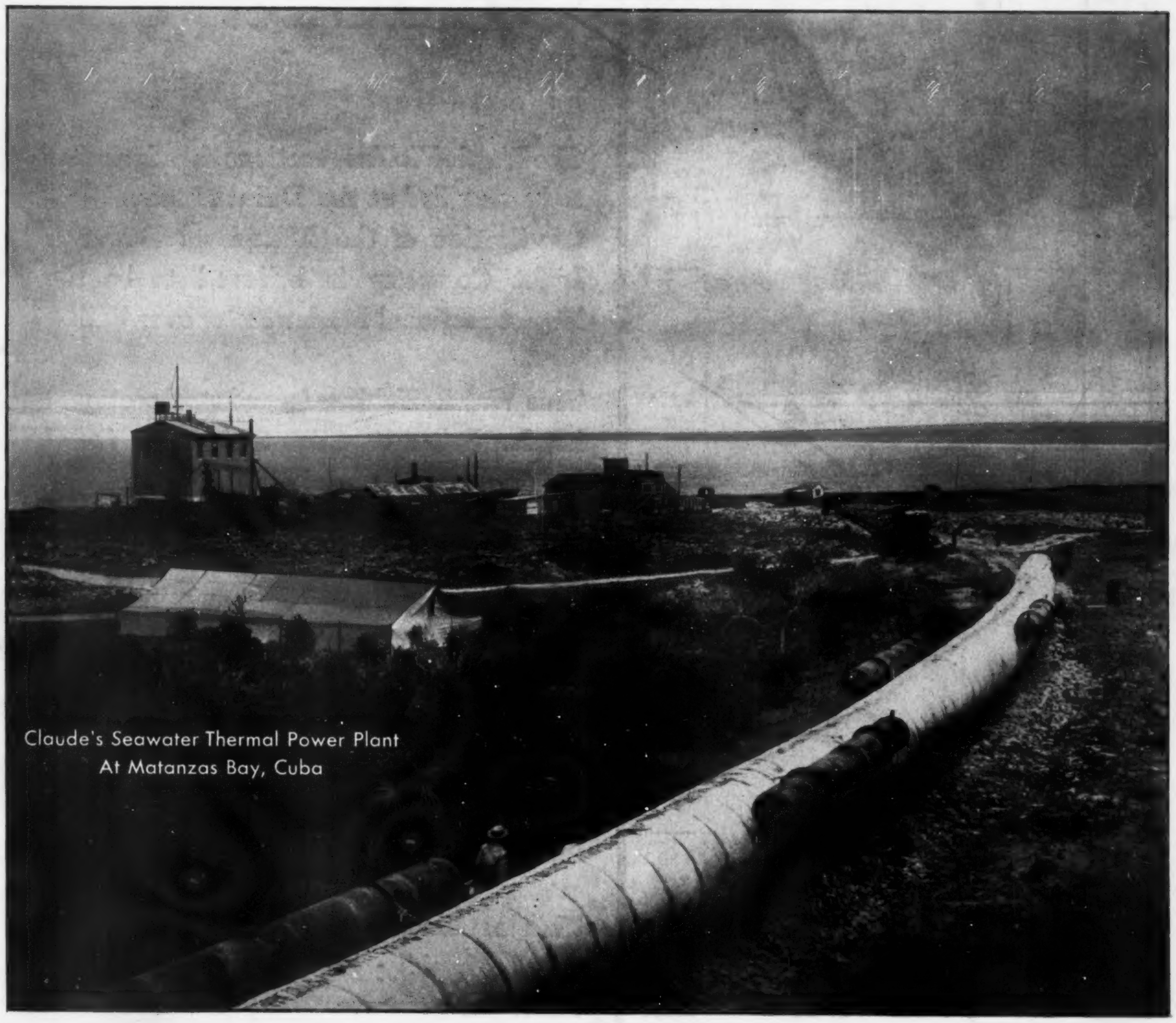
IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

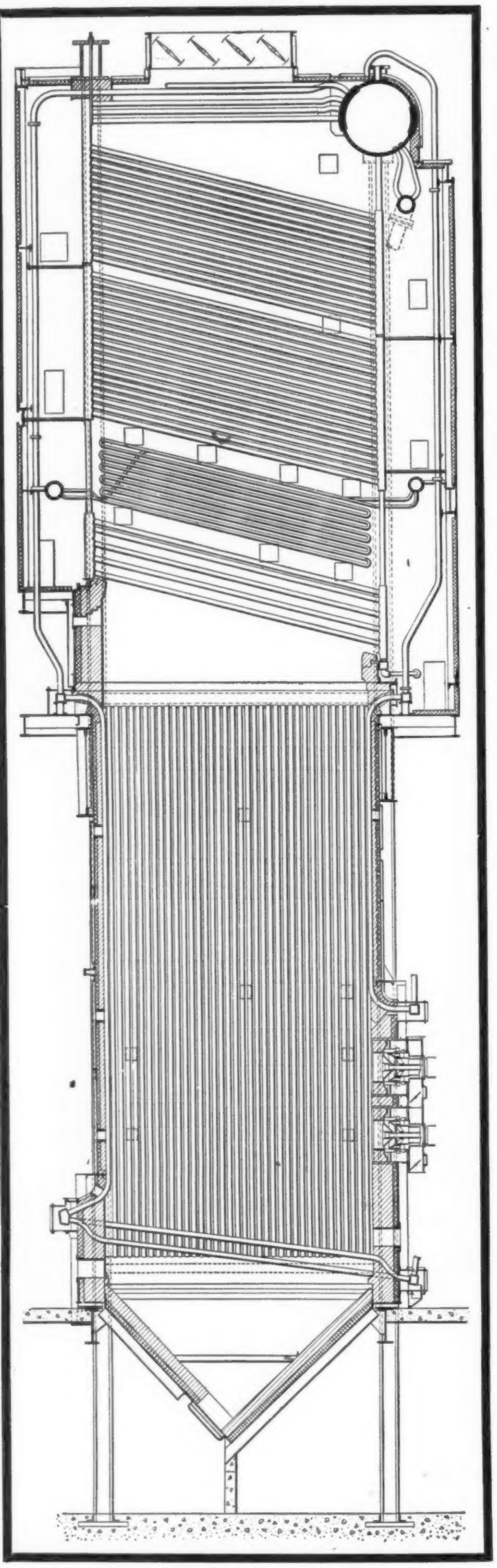


Claude's Seawater Thermal Power Plant
At Matanzas Bay, Cuba

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

December 1930

One Walsh-Weidner Forged Steel Sectional Header Boiler *to serve a* 25,000 kw. Generator



Sectional elevation of the Combustion Engineering steam generating unit now under construction at the Duluth Steam Electric Station of the Minnesota Power & Light Company.

The Walsh-Weidner sectional header boiler to be installed at the Duluth Steam Electric Station of the Minnesota Power & Light Company is believed to be the largest sectional header boiler ever built.

This Walsh-Weidner forged steel sectional header boiler contains 36,300 sq. ft. of heating surface; is of single pass design, 38 sections wide and 43 tubes high, including 3 rows of circulators. The steam pressure is 485 lb. per sq. in. with a total steam temperature of 760 deg. fahr.

The furnace is of the C-E Water-cooled wall construction and pulverized fuel is introduced through six Lopulco horizontal burners.

This installation is an excellent example of the rapidly growing trend of—one boiler per generator.

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Mechanical Engineering

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Beneficent Work for the Engineer

MECHANICAL Engineers have supplied all the peoples of the earth with marvelous inventions, but we must admit that many of those inventions are imperfect. We poison rivers with effluents, charge the atmosphere with noxious fumes, jar the nerves with vibrations, deafen our ears with noises, and offend our eyes with ugly factories and a countryside destroyed by our activities. I can imagine no more beneficent work for the engineer and the scientist than the removal of all those things which still mar the great and wonderful work they have done. May all of you who are coming on to the field that we are leaving carry our work a step further toward a larger and greater efficiency than we have ever known, and remove the defects of applied science without diminishing the great benefits which it has conferred upon mankind.

LOUGHNAN ST. L. PENDRED.

[From Presidential Address before the Institution of Mechanical Engineers, London, October 17, 1930]

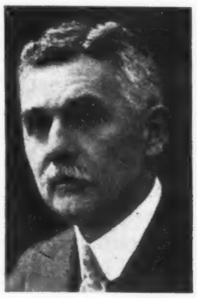
MECHANICAL ENGINEERING

Volume 52 December, 1930 No. 12

Power From the Tropical Seas[1]

Process Utilizing Difference Between Temperatures of Water at the Surface and at the Lower Depths—Expedients Employed in Locating and Submerging a Line of 6-Ft. Pipe a Mile and a Quarter in Length—Results With Experimental Plant—The Inventor's Predictions for the Future

By GEORGES CLAUDE,[2] PARIS, FRANCE



SIX months ago The American Society of Mechanical Engineers conferred on me, as a representative of the engineering profession of France, its Fiftieth Anniversary Medal. Having only a few weeks since succeeded in solving a problem which has held and continues to hold the interest of the engineering world, I pray you to find in this account of my work the manifestation of my deep gratitude for the honor done me and for the particular welcome which your great country has always extended to my inventions.

First of all, let me explain exactly what we have been trying to do. We have not been endeavoring to extract power from the waves, from the tide, from streams. What we had in mind, my friend Boucherot and myself, was to utilize the remarkable fact that, in tropical seas, through the paradoxical collaboration of the sun and the poles, an important and almost invariable difference of temperature is maintained between the surface sea water, which is continually heated by the sun to 75 to 85 deg. fahr., and the deep-sea water, which, because of the very sluggish flow from the poles to the equator, does not rise much above the freezing point, that is, 40 to 43 deg. fahr., at a depth of 3000 ft.

Regardless of the process employed, the principle of Carnot affirms that it is possible to utilize such differences of temperature to generate power. Several scientists and engineers observed this fact long before us, the first of them being my dear master and friend D'Arsonval as far back as 1882, followed by the American engineer Campbell, and the Italian engineers Dornig and Boggia. It is fortunate that I was not aware of this at the time I became interested, for, as you know, a beaten track has little allure for a good inventor, and quite probably we should have abandoned the trail before discovering what interesting things it finally led to.

While theory indicates that by utilizing our difference of temperatures it is possible to get power, it leaves us the choice of means. The inventors referred to proposed a means, namely the use of liquefied gases, vaporized under pressure by the tepid surface water, and then condensed by the cold water after their expansion in a motor. Manifestly such a solution is burdened by a number of inconveniences, one of them being the high cost of such evanescent substances, and another the necessity of transmitting enormous quantities of heat through the inevitably dirty walls of immense boilers with such a small difference of temperature.

It was therefore a decisive step that we took in demonstrating that, contrary to what might be expected, the sea water itself contains all that is needed for the *direct* utilization of such small differences of temperature, being able not only to furnish the heat needed, thanks to the surface water, and the cold, thanks to the deep water, but at the same time the motive fluid itself in the form of steam—all this without the inconvenience of transmitting heat through the walls of a boiler.

Principle on Which Process Is Based

For that purpose we had but to take advantage of the fact that a liquid—for instance, water—boils at a temperature all the lower the less the pressure upon it. This fact, being the very basis of our system, must be clear in your minds. Under the pressure of the atmosphere—over a ton on every square foot of the water in a boiler—the bubbles of vapor which constitute the phenomenon of ebullition cannot form and expand unless they receive the elastic force necessary to exceed this pressure, which necessitates heating the water to 212 deg. fahr. or its boiling point at atmospheric pressure. But if the pressure is lowered, for example, by pumping the air out of the boiler, it is obvious that the bubbles no longer require as much elastic force for their formation, and ebullition will take place at a temperature all the lower the better the vacuum. With a sufficient vacuum it is possible to boil ice itself, or at least a mixture of ice and water, and if one happened to fall into such boiling water, instead of

[1] Lecture delivered at a meeting of the Metropolitan Section of the A.S.M.E., New York, October 22, 1930.

[2] Member, Académie des Sciences de Paris, Société des Ingénieurs Civils de France, etc. A.S.M.E. Fiftieth Anniversary Medalist from France. M. Claude, scientist and inventor, was born in 1870. He has devoted many years to research and invention leading to the development of new materials and new ways of producing materials for industrial application, especially the liquefaction of air and of oxygen and hydrogen, the production of nitrogen and ammonia, and the industrial use of the new rare gases, argon, neon, and helium. One of his earliest achievements was the invention of the process in which acetylene is dissolved and stored under pressure in acetone, and which has made acetylene available for many uses in other countries as well as in France. His various investigations and achievements have shown his great originality along unusual lines. At the present time he is engaged in investigations relating to the industrial extraction of thermal energy from the sea, which he deals with at length in the lecture here published.

being scalded to death he might only catch a severe cold. And it is a much simpler matter to boil in a vacuum the comparatively very warm water from the surface of a tropical sea.

To illustrate, the sketch in Fig. 1 shows a tube T rising 10 meters from the surface of the tepid water in tank A to a closed vessel M, from the bottom of which a second tube T_1 descends to another tank B, also filled with water.

The air is now exhausted from the vessel M through the tube F, thereby producing a vacuum in it. Forced up by the atmospheric pressure, the tepid water of A ascends 10 meters in

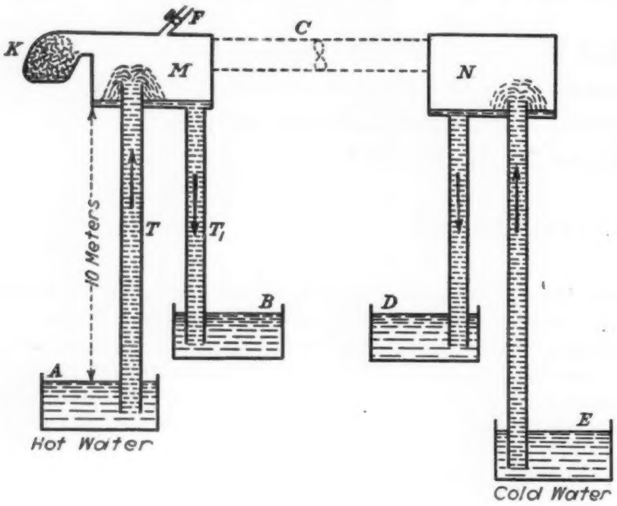


FIG. 1

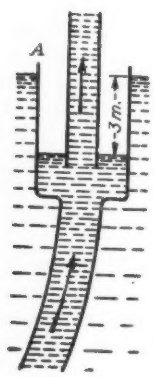


FIG. 2

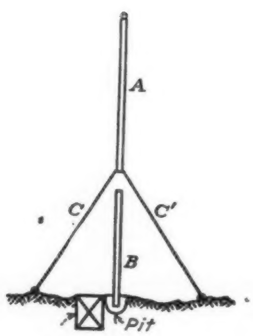


FIG. 3

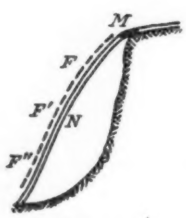


FIG. 4

the pipe T, since the atmospheric pressure equals that of a column of water 10 meters high, and enters the vessel M, where, because of the vacuum, it boils—not in a quiet, moderate way, as perhaps might be supposed, but with violence, with a kind of explosion, every drop bringing its own provision of heat—the steam so abundantly generated being immediately condensed by the crushed ice filling the receptacle K.

But in boiling, this water cools, owing to the subtraction of the heat of vaporization, and descends to tank B through the tube T_1. Thanks to the difference of level between A and B, it is continuously replaced by new quantities of tepid water, and due to this circulation the boiling continues as long as there is ice in K to condense the steam.

In practice we boil the surface sea water in the same way, but the steam produced by boiling, instead of being condensed by crushed ice, passes through a pipe C into another barometric vessel N in which circulates, in a similar way, cold water from the bottom tank E.

In short, we have, first, a barometric chamber where the tepid water boils violently and continuously, and then a second barometric chamber into which the steam from the first flows to condense under the action of cold water, this steam rushing through the pipe connecting the two vessels at a speed of 500 meters per second. If now in the path of this hyper-hurricane flow of steam we place a turbine, this turbine will run and generate motive power. That's all, but it is much, indeed, for it is easy to prove that it is equivalent to transforming the warm water of the tropical seas, in unlimited quantities, into a cataract 300 ft. high.

However, we had hardly uttered our proposition before protestations and objections fell on our heads like hail. First of all, so extremely low is the pressure of such steam that every one doubted whether it could be utilized; and it is strange, indeed, that no one had conceived of its possibilities prior to the very deviser of processes employing the highest pressures ever used in industry, who has in consequence to his credit the hyper pressures of the synthesis of ammonia and the micro pressures of the ocean's future vapor plants.

Further, dissolved gases constituted an objection that many critics delighted to present to us as insuperable. Unfortunately for these critics, they were most grievously mistaken in regard to the effect such gases would have in sea-water plants as compared with ordinary steam plants. Others declared that it would be impossible to prevent the deep-sea water from warming up too much during its ascent, when it is evident that even without any insulation at all the heating will be but insignificant in the huge tubes that will be used in the future.

But surely the most uncommon objectors were those who laughed, and are still laughing, at the project on account of the tremendous amount of power which they believe will be required to bring cold water up from the bottom of the sea. Now the theory of communicating vessels shows clearly that pumping cold water from the pit A (Fig. 2) requires only the very small amount of energy necessary to overcome the loss of head, very low in a large pipe, and the excess of density of the column of cold water, both totaling but 3 meters of head.

Finally, and more reasonably, there were those who thought it would be exceedingly difficult to submerge the immense pipes needed in the sea.

Unhesitating, with my usual optimism, to declare all of these objections either unwarranted or easily surmountable, I soon provoked the exclamations of all those who prefer to talk rather than act, of all those who make it their profession to criticize everything that is new and to dishearten all those who need audacity and self-confidence.

In short, I underwent once more an experience common throughout my whole career, namely, that it is much more difficult to fight against man than against matter. So numerous, so efficient today are the resources put at our disposal by nature and by science, that, in my opinion, material difficulties may always be mastered with some imagination, perseverance, and common sense. But man—that is another matter! However, objectors do not always succeed, and the more men declare I am wrong, the more I am eager to prove that I am right. I have done so, and must inform certain of these bad prophets that their criticisms have only served to spur me on in my work.

EARLY EXPERIMENTAL WORK

I started my work by performing before my fellow-members of the Academy of Sciences in Paris a little experiment which was entirely successful. I then undertook at my own expense and with the cooperation of certain Belgian friends, the tests at Ougrée, Belgium, after which, I dare say, some of my opponents had to hold their tongues.

On the day when a turbine with a wheel 1 meter in diameter ran at 5000 r.p.m. and generated 60 kw. under a difference of temperature of 20 deg. cent., proof of the thermodynamic part of the problem was furnished.

It remained to be determined, however, whether the idea of procuring cold water from the bottom of the sea was chimerical or not.

In a matter of this kind there is no precedent; all is unknown; theory no longer guides us, and we have to face that terrible adversary, the sea. That is precisely why it was impossible to ask people for considerable funds to engage in such a venture without giving them previously some confidence in the project.

Besides, it was necessary to ascertain on a sufficient scale some important eventualities. For instance, I had to be sure that, owing to its greater viscosity, sea water would not ruin our hopes by producing when boiled an abundance of foam that would blow the turbine to pieces, etc.

Inspired with confidence by the success of the Ougrée experiments, my friends who have followed me from the beginning of my career did not hesitate to give me the money and the *carte blanche* that I needed for so hazardous an enterprise.

This was all the more praiseworthy, because the test which I had conceived was to be carried out on a scale and at a cost that would seem entirely disproportionate to the results I expected to obtain.

For instance, large turbines able to operate under such an unusually low pressure have not been built as yet; and I had to content myself with the small one used at Ougrée, capable of generating only 60 kw. However, a very large and expensive pipe would be needed to feed that turbine; in fact, it would be perfectly useless to bring up water from the sea bottom if it were to arrive warm at the surface. Well, if the pipe had only the size required to feed the turbine, that is, not larger than 2 ft. in diameter, it would not be possible to insulate it sufficiently to prevent the complete warming up of the water during its ascent.

For this reason it would be necessary to use a pipe 2 meters in diameter, with pumps capable of handling its total flow—ten times that required by the turbine—so that nine-tenths of the water so pumped would have to be thrown back into the sea; and it was only at such a price that I could limit the drop in temperature to two or three degrees.

For this and other similar reasons my plant was condemned from before its construction to waste much more energy than it would ever produce, and to provoke accordingly the jests of those who will never understand that there are times where it may be wise to spend 80 kw. to obtain 25.

Such were the circumstances in which my friends agreed to follow me, without any hope of immediate industrial result, in my quest to obtain indispensable data for the calculation of future industrial plants, and it was for this alone that my collaborators and I had to work very hard during three years.

Considerations Leading to Location of Plant in Cuba

First of all I had to transport my Ougrée plant to a location on a tropical shore where it would be possible to connect it to the deep water, in order to run it under the actual conditions of practice.

Various considerations, especially the proximity of deep water, led me to choose the island of Cuba. At the close of 1927, investigations made to determine a convenient location for the plant, and conducted on my yacht *Jamaica*, brought a first disappointment. By this I mean proof of the existence of a high submarine cliff almost entirely around the island, which at 200 or 300 meters from the shore and at a depth of from 20 to 30 meters suddenly sinks almost vertically 100 to 200 meters. The pipe, instead of lying all along its length, according to my hopes, on the bottom of the sea, generally quite smooth enough, would have to drop down from the cliff into the abyss, floating in the water like an immense arch and at the cost of many difficulties.

Anxious to avoid subjecting the tube to the pressure of the submarine current—much dreaded on those shores swept by the Gulf Stream—I was led to locate the plant in Matanzas Bay, 10 kilometers from the city of that name. However, the protection afforded here proved to be little or nothing, and the depth available was regrettably small, less than 700 meters at the site chosen.

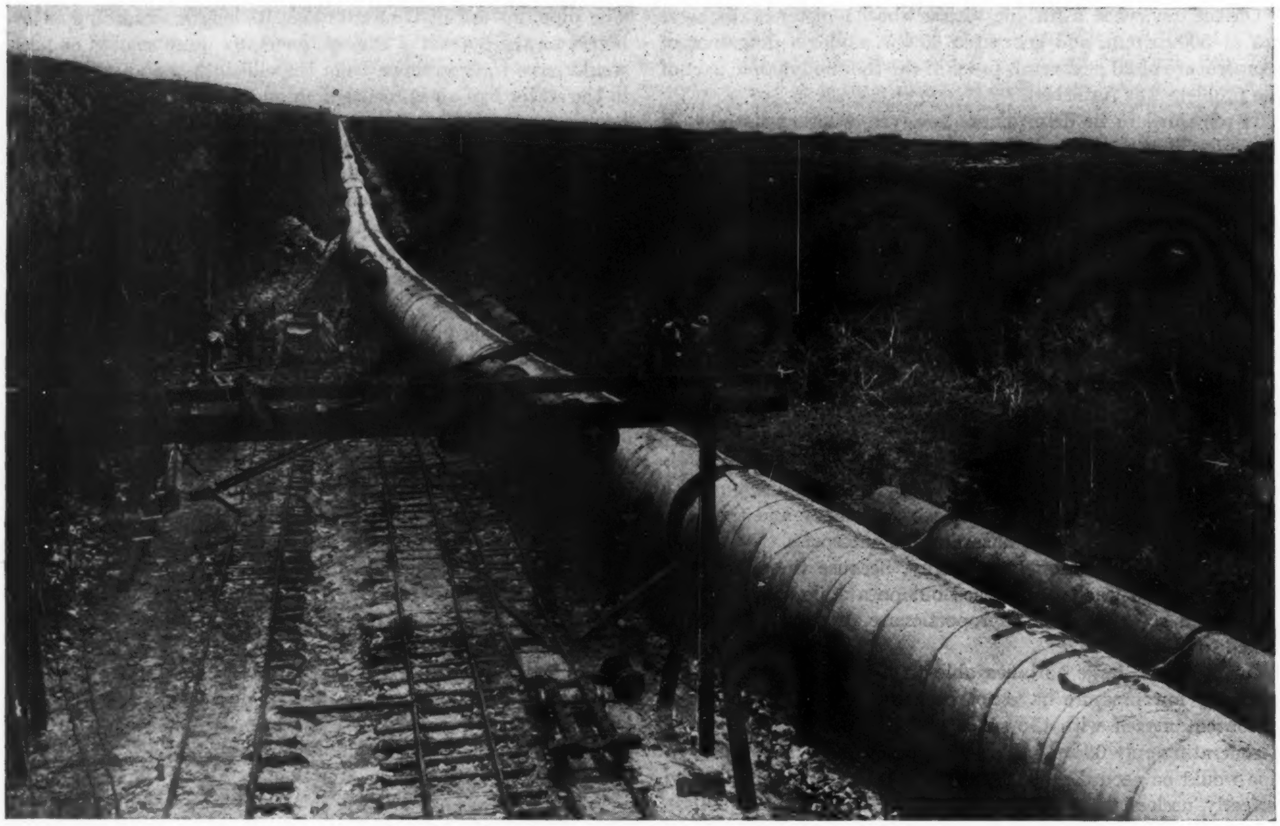
The plant, the pit for cold water, and the protection trench for the tubes were built at the rather unsatisfactory site chosen in the course of 1929. During this time, in Matanzas itself, we started to make the cold-water pipe out of 2-meter iron cylinders 2 mm. thick, deeply corrugated, sent from France, and welded together in lengths of 22 meters with flanged ends and rubber joints. A hard task, indeed, was this fabrication of a pipe 2 meters in diameter, 2 kilometers long, and weighing more than 400 tons. This work of welding, painting, and insulating was done in the custom house at Matanzas, and the 22-meter lengths, as soon as finished, were stored at the wharf of the Munson Line, 2 kilometers away, awaiting the moment when they would be connected together in the sea.

This last operation was to be executed quickly, at the ultimate moment, in the waters of this remote part of the bay, which I had been told was perfectly calm during the fine season. One day, however, these supposedly quiet waters got angry and sent to the bottom some hundred meters of tubing. I had now to devise some means of obviating this, and accordingly constructed a gigantic pontoon of double steel floats to break the motion of the waves. Behind this barrier it would be possible, I hoped, to join the lengths quietly. Alas! notwithstanding it was a notable improvement on what had preceded it, another fit of the angry waters convinced me that there was nothing to hope from that method—and the bad season, the season of cyclones, was rapidly coming. What could I do?

Well, some kilometers away on the other side of the bay, a large river falls into the sea, the Rio Canimar. I conceived mounting the tube on the waters of this river at once, before the arrival of the bad season, and far enough up the stream to avoid any agitation from the sea. The river is very sinuous, but I did not mind that, for I was sure that the flexibility of the corrugated pipe would allow it to conform easily to the windings of the river.

But I had first to dredge out the bar that obstructed the mouth of the river—250 meters wide; then to transport the separate lengths of pipe through the bay—a delicate operation under the perpetual threat of bad weather; then to unload these immense pieces in the waters of the river by means at first rather primitive but later improved; and finally to connect successively by divers the submerged elements, thus forming a train of immense length floating on the surface of the river.

Thanks to the devotion of my people, this hard task was accomplished in less than two months, but with the greatest difficulty. True, we no longer had to fear the stir of the waves, but instead we were at the mercy of the tidal currents flowing up and down the river, and of others more violent yet, caused by the torrential storms that every afternoon drenched the workmen to the skin. Not infrequently, arriving at the river at daybreak, we were enraged to find that some hundred meters of tube had grounded on the shore during the night, necessitating days of work to float it again. Finally we were forced to moor the tube fast to enormous blocks of concrete, sunk to the bottom of the river at stated intervals along its length.



VIEW SHOWING TUBE ON TRACK AND READY FOR LAUNCHING

LAUNCHING AND SUBMERGING THE MILE-LONG TUBE

At last the pipe was finished. On the 28th of August, 1929, it was easily pulled by means of a winch to the mouth of the Canimar, in order to get it away from the windings of the river, and it remained only to tow it across the bay in the direction of the plant, 7 kilometers away. But once more now the sea was the enemy, capable of dislocating the head of the tube at the first manifestation of rough weather.

Well, precisely two days later the wind blew, and because of a warning sent out of four days of worse weather, I had to give in haste the solemn signal to start work. Most of the 50 cables that held the pipe in the river were already cast off when I was informed that, whether through indolence, ill-will, incomprehension, or what—but at any rate a disaster, of the ten tugs that were to come to guide the tube into the middle of the river, four had missed the appointment. In face of such misfortune I gave the order to moor the tube again, when I was advised that the remaining ropes were breaking one after the other under the strain of the current, causing certain parts of the tube to be thrown to the shore. Willing or not, we had to start.

The operation, however, began perfectly and the tube had gone quite a distance into the sea, when, unable to correct the false initial direction, its middle part grounded on the undredged portion of the bar. The rear of the tube, continuing its motion, folded into an "accordion," and suffered severely. However, our efforts during this awful night succeeded in freeing the tube, and some hours later, at daybreak, it floated intact on the agitated waters of the bay. But the injury received in the river did its work, and 2 kilometers farther out the tube disappeared in 500 meters depth of water.

Disaster? Yes, indeed! But that was past, and what only mattered was the future. Nothing in the disaster affected the reality of our expectations. True, some means of realization had failed, but in return, I had gained in the struggle a precious experience. Nothing would prevent me, at the next good season, from starting anew but the question of money, for I feared that such a blow would cool some of my friends—though I am proud to say now that such did not prove to be the case. I solved this difficulty at once by deciding I should go forward, at my own expense, in case of another failure.

The principal thing I had learned in my hard adventure was to avoid any prolonged contact of the tube with the agitated waters; to abandon any idea of mounting it at the sea or river surface; to float the tube on their surface only to bring it into its proper position very rapidly, starting at the last moment.

For this purpose, Señor Vasquez, the distinguished engineer put at my disposal by the Cuban Government, suggested that we mount the entire tube on small trucks on a track, laid near the plant, from which it could be pulled to the sea by winches and tugs, and then submerged at the first certainty of a few hours of good weather.

Under the invaluable direction of my collaborator Daime, the fabrication of the tube started at the beginning of last March in large shops near the plant. This time, the tube—wrongly reduced to 1.6 meters in diameter—was made entirely on the spot, of Armco sheets 3 mm. thick, rolled, welded, corrugated, and insulated, while the track and the means of launching were constructed under the direction of Señor Vasquez.

On the 8th of June a first section of 150 meters of the tube was pulled to sea and submerged with complete success in the protection trench, 50 meters long, the end of the tube lying on the bottom of the cold-water pit. This first success brilliantly proved the superiority of this new method of launching. Some days later the pit was shut in by a thick wall of cement and the

trench filled up with concrete, thus protecting the tube from the wave action in these shallow waters near the shore.

On the 25th of June the main tube (A, Fig. 3), 1750 meters long, previously brought on the track to the immediate vicinity of the sea, was in its turn easily pulled to sea; then by tug traction on the two cables C, C', of calculated length and obliquely fastened to the shore on both sides of the tube, it was brought to position in exact prolongation of the first section B. Success seemed assured, since it only remained to sink the tube, when, instead of doing this as planned, from the shore to the high sea, some of the men, acting stupidly and against their written orders, caused the head of the tube to sink with extreme rapidity, thus throwing a tremendous strain on the mooring cables, which gave way—and the second tube went to join the first.

Had I been less inured to the misfortunes of an inventor's life, I should have felt rather disheartened this time; fortunately, long experience has proved to me to what extent perseverance and obstinacy are essential virtues for an inventor—perhaps the most indispensable. I may say that in practically the whole of my work, be it on the liquefaction of air, hyper pressures, the neon light, and so on, I have never known immediate success. Many times I have felt doubt and discouragement but had I given way at the first blow, I should have accomplished nothing.

It would then have been denying all my past if, crushed by such a non-technical failure, I had then abandoned the job, in spite of the improved method employed and the rapidly growing probability of success. Therefore I decided at once upon the making of a third tube which, built in 2 months, would have to be submerged before the arrival of the bad season, something possible only through the quite exceptional devotion of Mr. Daime. Some slight alterations of the program of the previous operation were made to prevent a new failure, and the Cuban Government took charge in guarding the operation, extending to me the aid of the cruiser *Cuba* and of the Army.

This third tube was successfully constructed and was then pulled to the sea on the 7th of September under the orders of Señor Vasquez; being hauled by two seagoing tugs on the two mooring cables of calculated length, it came very naturally to its correct position in line with the first section. Then, under my command, it was submerged by progressively filling its floats with water, the portion between the shore and the cliff going down first, then the remainder, care being taken to have this last part sink nearly horizontally to avoid any dangerous strain on the cables in case of previous sinking of the head.

The very flexible and extensible part M of the tube (Fig. 4) made accordion fashion to be capable of curving easily over the edge of the cliff, went down in exact position at the chosen place, the two cables that ran all along the tube binding the accordion to the part N descending from the cliff; this latter part being buoyed up in the abyss by means of permanent floats F, F', F'' filled with compressed air at a pressure slightly higher than that of the surrounding water.

At the same time, the shore end of the tube was brought into position on the bottom at a distance of 22 meters from the first section as planned, and the connection of the two ends by means of a third section of convenient length was easily made by divers some days later at a depth of 18 meters.

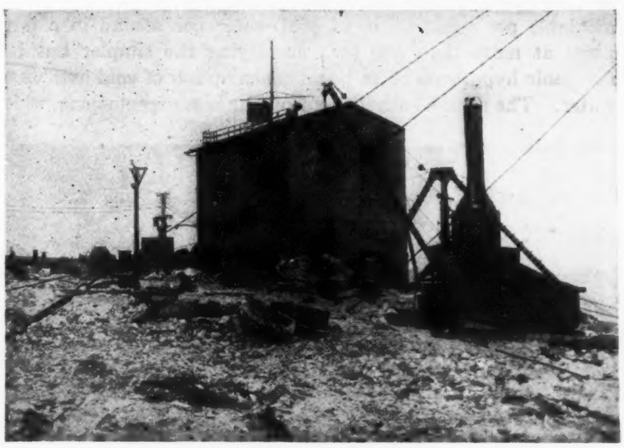
And now, ladies and gentlemen, we see how right I was a moment ago in asserting that obstinacy is the best quality for an inventor to have, especially when it is backed up by a rational idea and a devoted personnel. Had I given way at the first or second failure, nothing would have remained of all this work but the souvenir of a foolish attempt. As it turned out, however, all of my predictions came true, and in the most natural manner.

Results Obtained With Experimental Installation

The very day that the tube connection was made, the powerful Rateau pump of the pit was set working at the rate of 4000 cubic meters per hour; soon after, the water discharged became colder and colder, until finally it reached 13 deg. cent.—a good result, assuming that the temperature at the lower end of the tube was probably around 11 deg. cent. Thus disappeared my concern regarding the condition of the tube at the bottom of the sea.

Further, the loss of head in the pipe and the excess of density of the column of cold water, for an output of 1 cubic meter and a speed of half a meter per second in the tube, caused a depression in the pit of but 3 meters, which shows how little energy is needed to bring up cold water, and how trivial are those objectors

ANOTHER VIEW OF TUBE PRIOR TO LAUNCHING



VIEW OF THE PLANT

who condemn the process because of the tremendous amount of work they believe will be required to pump the cold water. I respectfully suggest that it is so long since these honorable gentlemen left school that they had better learn again the theory of communicating vessels. As a matter of fact, the above-mentioned results, obtained with a comparatively small tube in which the losses by friction are considerable, are very encouraging for the large pipes that will be used in the future.

Some days later an excellent test of boiling in vacuum drove away my fears that, owing to its viscosity, sea water when boiled would produce foam in excessive quantities. In this respect we found that it acts like pure water.

Finally, the turbine, that I had hesitated to mount at first for fear of its blowing to pieces because of excessive foam, was installed and its output progressively increased to 22 kw., a very satisfactory result, indeed, considering the very small difference

of temperature available because of the small depth of the bay, and obtained with condensing water but 14 deg. cent. cooler than the surface water and a consumption of 200 liters of cold water per second and the same amount of tepid water.

Among the things I ascertained, the most important refers to the amount of energy available from the water. After making some improvements on the condenser, I got 12.5 kw. with warm water at 27.5 deg. cent. and cold water at 17 deg. cent., which increased to 22 kw. with temperatures of 27 deg. and 13 deg., respectively. These variations in the cold-water temperature were due partly to curious fluctuations of the Gulf Stream, and partly to a leak in the tube near the shore; the pressures in the boiler and the condenser in this last case were respectively 23 mm. and 16 mm. for final water temperatures of 25 and 15 deg. cent. It is evident from these figures for the condenser pressure that that apparatus can be much improved. They refer to a consumption of cold and tepid water of a little over 200 liters per second each.

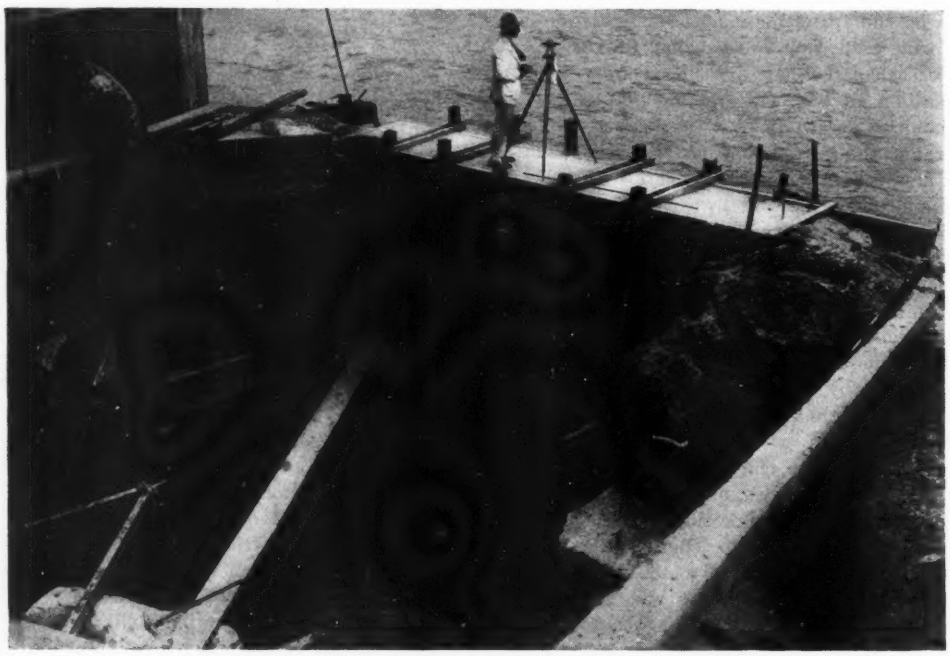
Predictions for the Future

Let us assume now that, as I have proved, the efficiency in such a plant increases as the *square* of the difference of temperatures. Without considering that the results mentioned refer to a very small amount of power, very far from good efficiency of turbine and generator, and condenser conditions that can be greatly improved, these figures mean 300 gross kw. or 240 net kw. for every cubic meter of cold water per second and a difference of temperature of 24 deg. cent., which difference is available most of the year in the vicinity of Santiago de Cuba. Taking now into account the imperfections and small size of my installation and the numerous possibilities of improvement, I estimate the energy available per cubic meter of cold water per second in a large plant at more than 500 kw., employing the simpler but less favorable hypothesis of an equal consumption of cold and warm water. The results entirely confirm our best expectations, which latter are being surpassed as far as regularity and ease of operation of such plants are concerned, although certain persistent critics, regardless of results and ignorant of what has actually been done, express increasing doubts regarding their veracity.

And, now, solidly backed this time by the facts, let me express my most complete confidence in the future of this process. Without underrating the problems that remain to be solved, I affirm my faith in the realization of wonderful plants running ceaselessly throughout the year, unaffected by the seasonal scarcity of water in streams or variations in the cost of coal; and I hold all this is not the task of a remote future, but one of tomorrow.

I have good reason to believe that there will be no serious difficulties encountered in the establishment of such plants, in the construction of the gigantic tubes required and their launching, in exposing them to the action of submarine currents or cyclones, nor even in their attack by submarine waters, probably owing to the trifling amount of oxygen in such waters. I know that the volumes of the boiling and condensing chambers will not be excessive. I know that the experimental plant at Matanzas represents as a result of my errors at the beginning a maximum of difficulties that will not be encountered in later industrial plants. I have collected the greater part of the information needed for the early installation of a plant of 25,000 kw. net, which, under the authorization of the Government, will probably be located in the vicinity of Santiago de Cuba.

In projects of this kind, however, only the hundreds of thousands of kilowatts are worth considering, and the proposed plant will be too small to verify my estimated installation cost of $60 per kilowatt, and will call for an expenditure of three to four million dollars. But Paris was not built in a day, nor even New York. And there is already much, I think, to warrant us in stating, as I do state today, that humanity has from now on the certainty that its industries will never lack the precious energy that actuates them.



The Cold-Water Pit

Engineering Revision an Essential Factor in Accident Prevention

By LUCIAN W. CHANEY,[1] WASHINGTON, D. C.

THE expression "engineering revision" was devised to afford a single, brief descriptive phrase covering the applications of engineering skill to the problems of safety in industrial plants. It includes such items as the following:

1 The design and location of the buildings with special reference to the health and comfort of the workers
2 Well-arranged transportation facilities
3 Ready and safe access to every place where workers are required to go
4 Adequate and well-arranged lighting
5 The safeguarding of machinery, either by the maker or by the owner, before being put into use.

There are two reasons why the items mentioned above have not been adequately stressed heretofore. The first is that before the compensation laws were passed, a worker suffering injury was obliged to appeal to the courts in order to secure any redress. In case of such appeal the worker might secure a verdict of such size as to cause the employer serious embarrassment, even to the point of putting him out of business. This rendered it necessary for the employer to lay stress upon "contributory negligence" on the part of the worker. When an injury occurred an effort was immediately made to discover something in the behavior of the worker which could be described as "carelessness" and serve as a defense against any claim which the worker might make. Considering the situation from this point of view has tended strongly to divert attention from the problems of "engineering revision."

The second reason is that the frequency of injuries has received an undue share of attention compared with their severity.

It is proposed to analyze the cases which it has been possible to accumulate with reference to the application of "engineering revision," and to contrast them with results which have arisen from greater personal caution.

The statistical material in this paper is almost entirely taken from the records of a large steel company. The identity of this company it is not permissible to disclose.

A few departments of the iron and steel industry will be first considered.

Blast Furnaces

In the blast furnaces under consideration hot-metal breakouts contributed to the severity rate more largely than any other cause in the early years.

By 1910 this cause had practically disappeared. This change was due to structural changes made which increased the resistance of the furnace to such an extent as to eliminate the "breakouts."

Second in importance as a cause of serious injury in the earlier years was asphyxiating gas. Breakouts and gas furnished 50 per cent of the severity rate in 1906. The reduction in severity due to gas was wholly owing to better engineering, such as developing better valves and carrying the gas mains high in the air.

When examination is made of the rates for those causes which are most affected by the personal care of the worker, it is evident that while reductions of great importance were brought about, they do not approach the results arising from engineering revision.

For illustration, severity in "falls of worker" in a seven-year period dropped from 1.87 to 1.40. In the same period "hot substances" went down from 15.14 to 0.43.

Even this does not fully represent the case. In the early years there were annually one or two deaths of painters at work on the stacks and stoves. The provision of a suitable sling and seat for painters entirely eliminated such deaths.

Personal care is a very important element in the reduction of accidents due to handling objects and tools. In frequency the decline was notable, but in severity it was only 0.30 from 1905 to 1913, an amount altogether insignificant when compared with that produced by engineering changes in hot substances and asphyxiating gas. It must not be forgotten that a part of this saving was the result of better engineering in the matter of safer tools kept in better condition.

From whatever point considered, these blast furnaces give evidence of the high importance of engineering revision in bringing about reduction of accident severity.

Open Hearths

The largest contribution to severity in the open hearths was made by the overhead cranes. This can be connected directly in a number of cases with structural defects such as absence of foot walks, poor access to the crane cage, and overhung gears. When these defects were remedied the severity rates declined markedly and continuously.

In injuries by hot substances, explosions other than ingot were the main cause of the early high severity rates. It is obvious that the carefulness of the individual workman can do little to prevent such explosions. When they do occur some workman is almost sure to be seriously injured. The present lowered severity rate is due mainly to revisions in structure and method which were primarily introduced to favor production. They both lessen the likelihood of explosions, and protect the worker when they do come. These structural revisions have not been rated at their true value from a safety standpoint, because, as stated above, they were installed in relation to production.

Power vehicles in the open hearths show a remarkable decline in severity.

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Contributed by the Safety Committee for presentation at the Annual Meeting, New York, N. Y., Dec. 1 to 5, 1930, of The American Society of Mechanical Engineers.

Considering cranes, hot substances, and power vehicles as a combined group, it is found that they declined from 13.0 to 2.3 or 82 per cent. In such cause groups as "handling tools and objects," where personal care is a large factor, the decline in severity is little or nothing.

The showing in frequency is very different. The cause groups where revision is the important factor declined 45 per cent, while "handling tools and objects" dropped 50.3 per cent.

Rolling Mills

The only group about which a positive statement is justified is that of overhead cranes. In these a material decline in severity is correlated with improvement in structure and operation.

Yards

In the yard operations there was a remarkable decline in the severity rates due to hot substances. This is almost entirely attributable to improved methods used in the transport of hot metal.

A study of the power vehicle as a cause of accident shows that a declining severity rate is related to the introduction of automatic couplers, the provision of adequate clearances, improved methods of loading such as the use of magnets, better systems of signaling, and the elimination of grade crossings.

Fatalities

When fatalities are adequately valued they are the major element in severity rates. It is therefore of high importance to give them proper consideration.

In 372 cases it was possible to determine whether engineering revision could have been applied to the prevention of the deaths. A list of these cases is given at the top of the adjoining column.

The cause groups listed will now be discussed in order.

Engines and motors caused three deaths. Two of these could have been prevented by guarding or removing projections on the moving parts.

Transmission gear caused three deaths. Two of these were due to projecting setscrews on shafts.

The largest number of deaths from any one cause happened from the operation of cranes and hoists.

One which occurred in operation of the crane was due to some defect in the electrical control.

Working machines	
Adjusting	2
Operating	2
Oiling and cleaning	2
Repairing	5
Objects flying	4
Unclassified	2
Cranes and hoists	
Operating	1
Oiling and cleaning	3
Repairing	3
Breakage	7
Falling loads	23
Hoisting and lowering	8
Unclassified	32
Hot substances	
Electricity	16
Explosions	12
Hot metal	15
Hot metal flying	25
Flames	5
Unclassified	3
Falling objects	50
Collapse of building	9
Stored material	7
From trucks	3
From buildings	4
Unclassified	27

17	Engines and motors	3	
	Transmission gear	3	
	Falls of persons		45
	From ladders	5	
	From scaffolds	6	
	From vehicles	1	
	From structures	20	
77	From other elevations	4	
	Into openings	3	
	Unclassified	6	
	Handling tools and objects		5
	Tools in hands of worker	1	
	Loading and unloading	3	
76	Objects flying from tools	1	
	Power vehicles		57
	Unclassified		39
	Flying objects n.o.s.	4	
	Asphyxiating gas	19	
	Heat	4	
	Moving objects n.o.s.	6	
	Unclassified	6	

combined with mechanical defects, no accident would have happened.

Unclassified causes incident to cranes and hoists contributed 32 cases, of which 10 were clearly due to defects such as the absence of footwalks or of proper means for reaching the crane cage.

To sum up, 43 out of 77 cases resulting in death in the operation of cranes and hoists could have been prevented by better design in the crane or by employing such operating methods as now prevail. It may be strongly suspected that into the other 34 cases there entered, not infrequently, elements of unsafe practice or imperfect structure for whose presence the workers were not responsible and which no education of them could remove.

Hot substances caused 76 fatalities. Sixteen of these were due to electric burns, and of these 13 were preventable by the kind of construction now commonly employed in electrical installations.

Of 12 deaths due to explosion, 7 were of a kind which could scarcely occur with improved modern practices.

Hot metal caused 40 deaths, and in 32 of these bad methods or imperfect structure had a part. For each condition under which these 32 cases occurred, an effective remedy has been found.

Not fewer, therefore, than 52 out of 76 deaths due to hot substances presented engineering-revision problems.

Of 50 deaths due to falling objects, 29 were preventable by appropriate structural changes.

Falls of workers were responsible for 45 deaths. Of these, 22 might have been prevented by better scaffolds, stairs, platforms, railings, and other revisions which are now regarded as a matter of course.

TABLE 1 CLASSIFICATION OF ACCIDENTS BY NATURE OF INJURY AND BY ANATOMICAL LOCATION

Nature of injury	Head, general	Skull	Scalp	Face	Neck	Back	Chest	Abdomen	Pelvis	Arm	Hand	Leg	Foot	Not located	Total
Bruises, cuts, lacerations	3	...	.	.	1	2	5	26	..	..	.	..	..	..	37
Bruises, etc., with infection	1	...	.	1	1	1	1	..	..	1	4	2	..	..	12
Burns and scalds	..	...	6	1	..	8	74	26	..	2	.	19	..	6	142
Burns, etc., with infection	..	...	.	.	..	..	...	..	..	..	1	1	..	..	2
Concussions	5	...	.	.	..	..	...	..	..	..	.	..	..	..	5
Dislocations	..	...	.	.	1	..	...	..	..	..	.	..	..	..	1
Fractures	..	218	.	3	20	13	220	..	33	6	.	65	7	..	585
Fractures with infection	..	...	.	.	..	..	...	..	..	1	1	1	..	..	3
Traumatic dismemberment	4	...	.	.	..	..	...	..	..	6	.	9	4	1	24
Asphyxia	..	...	.	.	..	..	...	..	..	..	.	..	..	71	71
Electrocution	..	...	.	.	..	..	...	..	..	..	.	..	..	23	23
Heat exhaustion	..	...	.	.	..	..	...	..	..	..	.	..	..	7	7
Unclassified	..	...	.	.	..	..	...	3	..	..	.	1	1	39	44
Total	13	218	6	5	23	24	300	55	33	16	6	98	12	147	956

Three oilers were obliged to approach moving parts which were not properly guarded.

Seven cases due to breakage were all preventable by better design or greater strength.

Of the 23 cases due to falling loads, some happened because of weakness in the crane, imperfect chains, faulty signals, or some other condition which the management should have discovered and taken care of. Some of these cases involved some element of contributory negligence, but if this had not been

Of 57 deaths due to power vehicles, 34 were chargeable to such as the following: Failure to install automatic couplers, inadequate clearances, grade crossings upon which men could come without being able to see the approaching locomotive, bad signal systems, permitting, for example, cars to be shunted down upon standing cars under which men were working. None of these present any serious difficulties to the engineer.

There were 19 deaths from asphyxia. All these were related to imperfect gas mains, unventilated inclosed spaces, leaky valves, or other conditions involving revision.

To summarize this examination, 212 out of 372 deaths (57 per cent) could have been prevented by some form of engineering revision. This can be said without qualification. It cannot be said, however, that all the other 43 per cent would have been amenable to educational methods in response to which caution would insure safety. In only about 10 per cent of these deaths would it be safe to say positively that the man's own carelessness clearly appears as the major factor.

Nature of Injury in Fatal Cases

Further light upon the possibility of reducing the number of serious accidents may be derived from a study of the nature of the injury causing death. Nine hundred and fifty-six cases were available (see Table 1).

Fractures (585 cases) are the most frequent cause of death. When severe enough to cause death these involve nearly always an element of crush in the injury. A critical study of these cases discloses that in a majority of them there is clear evidence of faulty structure which might have been remedied. For example, a man's life was crushed out between a moving car and a post beside the track. What was needed to make him safe? Six inches more of space. This could have been given easily at the time of construction, and almost without cost. When once built, however, it appeared so difficult that nothing was done until after the man was killed.

Next in importance to fractures are burns and scalds, with 136 cases. Of these the most striking are 4 cases of cremation: 1 due to falling into a furnace and 3 to being overwhelmed by molten metal. In the cremation cases rearrangements were worked out after the catastrophes which very much lessen the chance of a similar happening. In a large proportion of the less striking cases some structural inprovement lessening the hazard has been made subsequent to the accident.

The fact that infection was formerly a very serious menace is attested by the fact that 23 deaths occurred in which without this complication there would have been recovery. This emphasizes very strongly the great value of emergency treatment as a life saver, with sufficient insistence upon it to secure prompt report of even trivial injuries.

The 23 cases of electrocution were largely needless. They represent faulty installation or a method of work which would not now be tolerated.

The same statement can in a measure be applied to the 71 cases of asphyxia. Sufficient care in construction will largely do away with this death hazard.

Finally, 24 cases are presented which afford a startling climax to this presentation. These are cases of traumatic dismemberment in which arms, legs, or heads were burned, sheared, or forcibly torn from the body. Of the nine cases of legs so lost, one leg was burned off by a hot rod in a rod mill. The feet lost were ground off in the exposed gears of the transfer tables of rolling mills. Four decapitations are recorded. Of these two were due to being caught by the hot rod loop in the rod mills; the other two were the result of power-vehicle accidents. The question of the reasonableness of the costliest efforts to render such events impossible can scarcely be debated.

Engineering Revision Suggested by Safety Committees

The analysis so far presented depends upon the accuracy with which the author of the paper has interpreted the reports to which he had access. It is well now to consider how similar records have impressed safety committees who have considered them.

The company from whose records Table 2 was prepared has for many years carefully considered each case involving lost time. First, the safety committee of each plant would go over the records and reach a conclusion regarding classification. The scrutiny would not stop at this point. At stated intervals the conclusions of the plant committees would be transmitted to the company safety committee, who would again carefully review the conclusions.

TABLE 2 ANALYSIS OF DISABLING ACCIDENTS

	Number of cases of disabling accident			
	Preventable by			
Disability of	Engineering revision	Care of worker	Trade risk	Total
Six weeks and under	56	973	381	1,410
Over six weeks	16	100	48	164
Death and major mutilation	39	10	19	68
Total	111	1083	448	1642
	Percentage distribution			
Six weeks and under	4	69	27	100
Over six weeks	10	60	30	100
Death and major mutilation	57	15	28	100
Total	7	66	27	100

It is probable that no group of cases in the country has received more careful attention before a final decision.

The relation of this compilation to the question of the importance of "engineering revision" is found in the percentage-distribution column headed "preventable by engineering revision."

It will be noticed that of accidents causing six weeks' disability or less, only 4 per cent could have been prevented, in the judgment of the committees, by engineering methods. In cases causing over six weeks' disability, 10 per cent could have been so prevented, while in cases involving death or major mutilation, the percentage was 57.

It is worthy of remark that this 57 per cent is the same as that found in the study of earlier records by the Bureau of Labor Statistics. That the figures are identical is merely a coincidence, but they are suggestive.

Extent of Reduction

In conclusion, it is appropriate to consider in the light of the foregoing presentation what may be regarded as a reasonable reduction in accident rates. The conviction that there must always remain an "irreducible minimum" of accidents rests mainly upon the idea that the chief cause of accidents is human recklessness.

Since a perfected humanity is hardly to be looked for in this generation, the hope of an industry measurably free from accidental deaths has seemed an "iridescent dream."

The foregoing analysis proves quite conclusively that—

1 Education and the development of interest among the men will come near to eliminating minor injury.

2 Adequate "engineering revision" will reduce serious injuries to an as yet undetermined degree.

The degree of such reduction is largely conditioned on what shall be regarded as "adequate." It is certainly possible to imagine structures and apparatus so strong, so well designed, so intelligently operated, that failure and consequent death will be the rare exception. The possibilities of improvement from an engineering standpoint are almost limitless.

Management's Responsibility for Industrial Accidents

By L. P. ALFORD,[1] NEW YORK, N. Y.

"Who is responsible for an industrial accident?" This question has been a favorite topic of discussion since the beginning of the safety movement. Gradually there has come a change in the method of answer. At first the workman was held responsible for whatever befell him; now there are those who put by far the major part of the final responsibility for industrial accidents upon management.

This newer point of view insists that an industrial accident is evidence of some fault of control of the operating conditions and forces. For this control the executives and members of the supervisory force are responsible. One study assessed 88 per cent of all accidents against the supervisory force.

The Committee on Safety and Production, American Engineering Council, formulated this fundamental of management: "Maximum productivity is dependent upon the reduction of accidents to an irreducible minimum," and management "must initiate, direct, and control ways and means of keeping accident frequency and severity rates at an irreducible minimum."

A FAVORITE topic of discussion in meetings devoted to safety and industrial accidents has been, and still is, "Who is responsible for an industrial accident?" As more facts have been accumulated and studied, as management has become more clearly defined, as industrial organization has been better understood, there has been a change in the answer to this query, a gradual shift of viewpoint in regard to accident responsibility. At first it was held that the workman was responsible for whatever befell him; then it was seen that he had no control over many factors in his surroundings; now there are those who put by far the major part of the final responsibility for industrial accidents upon the shoulders of management.

By management, in this connection, is meant the group of executives and supervisors who, in any industrial establishment, make decisions for, and give orders to, the employees or workers.

By "industrial accident" is commonly meant any accidental happening that causes injury to a person employed in an industrial establishment. However, a broader interpretation is justified, for an accidental happening, while not causing injury to a human being, may cause loss or delay through damage to equipment or material, or interruption of the productive process.

S. J. Williams, when Engineer for the National Safety Council, stated this relationship between safety and efficiency in this way:[2]

> Suppose a box falls off a loaded truck and kills a man. For every such case which results in a physical injury there will be perhaps a hundred cases where a box falls off, but without injuring any one. But in every one of these hundred cases either the box will be broken, or in any case the truck will have to be stopped and the load repiled. While, therefore, there will be only one case of physical injury, there will be a hundred and one cases of inefficiency. An accident is something gone wrong, and it can result only from causes which have their effect over a far wider field than that of the immediate accident itself. The physical injury is only the spectacular evidence of some underlying maladjustment in the same way that a headache is only an alarm bell that calls attention to something that is wrong within.

Industrial Accidents Evidence of Fault of Control of Operating Conditions and Forces

An industrial accident, therefore, must be considered as evidence of some fault of control of the operating conditions and forces. The exception to this statement is found in those few cases where random causes, which cannot be predicted and controlled, produce the accidental happening. Where control is perfected, accidents are brought down to the irreducible minimum, which, in numerous cases, has been zero for considerable periods of time so far as lost-time accidents are concerned.

Responsibility for a "fault of control of the operating conditions and forces" in an industrial establishment can be assessed only against the center of management. This center is that individual, or small group of individuals, who exert the directing will in that concern. In this center is the managerial skill which makes for success; while its lack leads on to failure.

Upon this center of management rests the responsibility for initiating a program for accident prevention, and for the continuing care to make such a program effective. The Committee on Safety and Production of the American Engineering Council made this emphatic statement:[3]

> Inasmuch as the top management of any industrial concern is composed of the major executives, and satisfactory safety performance comes only from the exercise of managerial skill, the responsibility for initiating a program of safety improvement rests squarely and inescapably upon the shoulders of the leading executives. In other words, the key to the new safety movement, which will substantially reduce the number and cost of accidents now being experienced, is the industrial executive.

The foundation for this statement is an extensive survey which gathered the accident experience and production record of nearly two and one-half million workers and over fifty-four

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[2] "Safety and Production," a Report of the American Engineering Council, p. 8.

[3] "Safety and Production," p. 33.

billion man-hours of industrial operation. The thesis that the committee set out to explore is: "The safe factory is an efficient factory." The method of attack was to determine the relationship between the changes in safety and production expressed as a correlation. Quoting from the report:

The coefficient of correlation....is 0.835. Perfect correlation, that is, causation, is represented by the coefficient 1. The degree of correlation is therefore impressive.... The result leads unmistakably....to the implication that there exists a high degree of correlation between industrial safety and industrial productivity, and that the combination of low accident rates and high production rates is possible of attainment by any industrial group.[4]

HIGH PRODUCTION RATES IMPLY LOW ACCIDENT RATES

Bearing directly upon the topic of this paper is another inescapable implication: The managerial direction that can secure a high production rate can also attain a low accident rate. The responsibility for the one is concentric with the responsibility for the other.

Another declaration of the Committee on Safety and Production sums up the significance of its report and bears directly upon this matter of managerial responsibility:[5]

The committee feels deeply that the situation presented by this report, the remedial measures recommended, and the improvement clearly possible, deserve the thoughtful consideration of industrial executives. Industry is admirably efficient, its achievements are a source of justifiable national pride, but its processes must be freed from inexcusable human wastage. Its operation must no longer accumulate a preventable cost in human lives and curtailed energies. When these losses and costs have been eliminated or brought down to the irreducible minimum, then and then only will the highest productivity be secured and the most efficient operation realized. The dynamic force which can attain this highly desired objective resides in the management. Therefore a responsibility which cannot be evaded rests upon the managers and executives of industry to make safety a major interest and a continuing care.

H. W. Heinrich,[6] from an extensive investigation of reports of industrial accident cases, gives as his matured judgment that 98 per cent of all accidents are preventable, and that 88 per cent of the causes of all accidents are supervisory.

Any major result in industrial operation is the sum of many efforts acting in and through a complex organization. Thus it is very difficult to connect closely such factors as managerial backing of safety in a given plant and an improvement in accident experience. However, A. MacD. Hughes,[7] in a recent letter to the author of this paper, has given the record for his plant:

In the fall of last year, at the request of the management of Manville Factory, a drive was planned for 1930 on the safety movement. The results so far obtained for this year have been very satisfactory, and I am attaching hereto a recapitulation of our accident experience for the first six months of 1929 and for the same period of 1930. [See Tables 1 and 2.] You will note by comparison that we have accomplished considerable on the question of cutting down compensation costs from $14,000 for 1929 to $4100 for 1930. I would call your attention to the fact that during 1929 we had only eight departments, as you will see by referring to the experience of 1929, whereas in 1930 we have nine departments, or the addition of the Shingle Building. This building started in operation in March of this year with inexperienced help, resulting in a deluge of "lost-time" accidents, and the compensation for this building alone was $2100. It is therefore only fair to compare eight departments of 1930 with the same eight departments of last year, which would make our compensation for the first six months of 1930, $2000, or a net saving of $12,000.

TABLE 1 ACCIDENT EXPERIENCE, MANVILLE FACTORY, FOR FIRST SIX MONTHS OF THE YEAR 1929

Rating	Department	Total accidents	Lost-time accidents	Permanent injuries	Total days lost	Frequency rate[1]	Severity rate[2]	Estimated medical cost	Estimated compensation cost	Cost per $100 of payroll
1	Packing........	12	3	1	112	11	0.42	$ 116.50	$ 538.12	$0.48
2	Pipe covering...	29	12	2	321	44	1.18	173.50	903.90	0.73
3	Textiles.........	68	15	5	430	24	0.71	425.40	2612.10	0.97
4	Mechanical.....	25	4	3	185	13	0.61	391.00	1712.53	1.09
5	Magnesia.......	14	7	1	383	29	1.61	387.75	1625.80	1.49
6	Roofing.........	20	13	5	354	52	1.42	449.65	1765.07	1.58
7	Clutch facing....	8	4	2	198	34	1.66	140.50	1758.77	2.90
8	Paper mill......	23	13	4	651	56	2.81	489.50	3254.13	2.91
	Totals........	199	71	23	2634	31	1.15	2573.80	$14170.42	$1.33

[1] "Frequency rate" means number of "lost time" accidents per million man-hours worked.
[2] "Severity rate" means number of days lost per thousand man-hours worked.

TABLE 2 ACCIDENT-EXPERIENCE REPORT, MANVILLE FACTORY, FOR FIRST SIX MONTHS OF THE YEAR 1930

Rating	Department	Total accidents	Lost time accidents	Permanent injuries	Machine accidents	Estimated days lost	Frequency rate[1]	Severity rate[2]	Estimated medical cost	Estimated compensation cost	Cost per $100 of payroll
1	Roofing........	62	8	0	5	68	47	0.40	$ 151.20	$ 100.00	$0.23
2	Textiles........	235	6	0	34	39	17	0.11	473.45	15.72	0.26
3	Magnesia......	51	10	0	3	123	46	0.57	187.75	202.86	0.28
4	Pipe covering..	136	9	0	6	37	56	0.23	329.90	......	0.34
5	Paper mill.....	46	8	0	15	123	52	0.79	135.69	260.85	0.44
6	Clutch facing..	95	4	0	11	43	46	0.50	216.05	88.57	0.65
7	Mechanical....	132	15	1	8	173	54	0.63	570.97	815.80	0.77
8	Packing.......	123	8	1	7	122	44	0.67	484.20	494.24	0.97
9	Shingle........	154	28	3	12	422	236	3.56	780.95	2153.85	4.52
	Totals.......	1034	96	5	101	1150	56	0.67	$3330.16	$4131.89	$0.73

[1] "Frequency rate" means number of "lost time" accidents per million man-hours worked.
[2] "Seveiity rate" means number of days lost per thousand man-hours worked.

It is rather difficult for one to give a definite, prescribed formula for accomplishments on safety. I can say frankly, however, that results will follow if the safety movement gets 100 per cent backing of the management, with constant spreading of emphatic safety propaganda to educate the masses.

The relationship between industrial-accident experience and labor turnover indicates one point of managerial attack in an effort to improve the accident record. It also emphasizes the complexity of the safety problem.

INDUSTRIAL ACCIDENTS AND LABOR TURNOVER

Chaney and Hanna pointed out as early as 1918[8] that the fact that the green man is particularly subject to accident has been recognized to some extent, and in a number of plants special efforts have been made to train and caution him. But the full effect of this factor has not been perceived. Careful analysis indicates that inexperience plays a very important part in accident occurrence, and suggests that it may be an extremely influential factor in the increase in accident rates which almost inevitably accompanies an increase in business activity.

Chaney, writing further on this matter,[9] gives these records: The accident rate for employees with less than six months' service was 37.1 per 1,000,000 hours of exposure; for those with three to five years' service, 14.1; and for those with ten to fifteen years' service only 2.8.

[4] "Safety and Production," p. 30.
[5] *Ibid.*, p. 36.
[6] "Laws of Management Applied to Manufacturing," by L. P. Alford, p. 20.
[7] Manager, Personnel Department, Johns-Manville Corporation.
[8] "The Safety Movement in the Iron and Steel Industry," 1907–17, by L. W. Chaney and H. S. Hanna. U. S. Bureau of Labor Statistics, 1918, Bulletin 23, p. 132.
[9] "Causes and Prevention of Accidents in the Iron and Steel Industry 1910–19," by L. W. Chaney: U. S. Bureau of Labor Statistics 1922, Bulletin 298, p. 167.

Kitson and Campbell[10] studied the reports of 28,939 industrial accidents in a variety of industries including the manufacture of cutlery, building railway cars, manufacture of gas and coke, and production of automobiles. They "show a ratio of approximately one accident to every one of the 27,012 new men hired. This is four times as great as the incidence of accidents among the total number on the payrolls examined, and in itself constitutes striking evidence that new employees are powerful factors in raising the number of accidents."

While this evidence indicates that high labor turnover may adversely affect accident experience, it seems to be equally true that active attempts to improve the accident record will reduce labor turnover.

J. R. Stegman,[11] in summing up the results of the safety program in his works, observed: "Employee turnover has been greatly reduced."

The literature of the safety movement records many cases of no-lost-time accidents for large numbers of workers and for considerable periods of time.[12] Such enviable performances indicate how far management can go in planning and carrying through a safety program. They show that the irreducible minimum of accidents in those particular cases and periods is zero. Unfortunately the total number of such cases is comparatively small.

The Committee on Safety and Production, previously quoted, recognized the existence of an irreducible minimum:[13]

> ...there is a close relationship so pronounced and consistent throughout as to indicate a fundamental of management, which may be stated as follows: Maximum productivity is dependent upon the reduction of accidents to an irreducible minimum.... This fundamental clearly indicates that if management desires maximum productivity, it must initiate, direct, and control ways and means of keeping accident frequency and severity rates at an irreducible minimum.

The facts presented in this paper and the opinions quoted support the declaration that the responsibility for safety in industrial operation rests upon the management, upon the executives, and supervisors. No better closing can be added than the two sentences that end the "Findings of the Committee" in the Report on Safety and Production:[14]

> In thus fixing responsibility so definitely, the committee does not place any blame whatsoever for conditions as they exist, nor for any aspect of the present situation. It does seek, however, to show where lies the responsibility for initiating imperative improvements.

[10] "Relation Between Labor Turnover and Industrial Accidents," by H. D. Kitson and Claude Campbell, *Journal of Industrial Hygiene*, vol. V, no. 3, p. 94.

[11] "By-Products of a Safety Record," by J. R. Stegman, Manager, Harriman Brothers White Lead Company, *National Safety News*, November, 1925, p. 81.

[12] See "Industrial Safety Organization," by Lewis A. De Blois, and "Safety and Production."

[13] "Safety and Production," pp. 69–70.

[14] *Ibid.*, p. 37.

Permanence of Dimensions Under Stress at Elevated Temperatures

IT WILL be generally conceded that one of the most difficult problems before the metallurgical and engineering world at the moment is that of determining fundamental data for the use of the designer which will enable him to be certain that the stresses with which he has to deal at elevated temperatures can be carried without deformation.

The author writes under no misapprehension of the difficulties in the way of a complete solution. The study of the properties of steel at elevated temperatures is receiving much attention, but it will become easier when agreement is obtained as regards the more simple problems associated with the characteristics at ordinary temperatures. Can one have permanence of dimensions under stress at normal temperatures? Dickenson, Bailey, and others assert that there is no absolute permanence; but if this assertion is examined as to their ultimate meaning, qualifications are made which leave the assertion simply in the position of an abstract idea at present incapable of proof or disproof, owing to our inability to deal experimentally at present in an effective way with the time factor. Engineering experience over long periods of time, however, really gives the answer, which is, of course, that for all practical purposes permanence of dimensions under heavy stress is undoubtedly attained within measurable accuracy over very long periods of time. The question is, however, of great interest, and it is, indeed, theoretically necessary to endeavor to establish the fact one way or the other by experiment.

One such experiment is still continuing in the Brown-Firth Research Laboratories, and may be usefully described, since the results are of sufficient interest in their bearing upon the problem. The author recently postulated that to be sure that a bar 10 ft. in length submitted in tension to a given stress would not increase in length by plastic deformation to a greater amount than 0.001 in. in a period of twenty years, the rate of flow under that stress must be determined to be less than one twenty-thousand-millionth of an inch per inch per hour. The experiment consists of stressing, at 25 tons per square inch, a strip of cold-rolled rustless austenitic chromium-nickel steel—limit of proportionality, 27.4 tons per square inch; 0.1 per cent proof stress, 60.7 tons per square inch—the extensometer being constructed also of rustless steel. The selection of rustless materials removes a danger of corrosion during the life of the experiment. Since June 1, 1929, to date, June 12, 1930, there has been no movement within an accuracy of measurement of one forty-thousandth of an inch. The length between gage points of the specimen is 8 in. A simple calculation, therefore, will disclose that if movement is taking place under this very considerable stress, it is, at any rate, of a less order than one two-thousand-eight-hundred-millionth of an inch per inch per hour. The nature of this experiment will bring home the extreme difficulty of dealing with the whole question of stability of dimensions.

The time for such an experiment may be shortened by increasing the sensitivity of measurement; for instance, if the measurements be made to an accuracy of a millionth of an inch it may be reduced to a period of a few months. But the effect of temperature variations, inducing changes according to the coefficient of expansion of the steel, requires to be dealt with. Indeed, a casual draft, changing the temperature of a 10-in. test piece 1 deg. cent., would change the extensometer reading by one ten-thousandth of an inch; therefore it will be seen that the value of supersensitive measurement of dimensions is entirely at the mercy of the provision of a sufficiently constant temperature. In any case, the reading-off of the actual temperature and of the dimensions must always be synchronized. Dr. W. H. Hatfield in a paper before the Prague meeting of the Iron and Steel Institute. Reprinted from *The Engineer*, London, Oct. 10, 1930, p. 408.

American Management in Europe

Characteristics of European Industry Noted During Three and a Half Years Spent in Installing American Methods in a Variety of Plants and Mines in Nine Different Countries

By WALLACE CLARK,[1] NEW YORK, N. Y.

THE growing interest of European industrialists in American methods of management is well known. For a long time they believed that the purchase of the most efficient machines and equipment would bring them American prosperity, but they have learned, as we did over here, that management is quite as important as machines and processes.

As a body of technicians The American Society of Mechanical Engineers may be interested in some of the characteristics of European industry noted in the author's daily work of installing management methods and how those methods are adapted to foreign conditions. During the last three and a half years in the plants and mines of nine European countries, his organization's clients have been engaged in the following industries: mines of salt, iron ore and coal, blast furnaces, foundries, forges, rolling mills for steel, brass and copper sheets and tubes, locomotives, railway cars, automobiles, airplane motors, agricultural and textile machinery, cellulose and mechanical pulp, paper, lumber, printing, lithographing, clocks, screw-machine products, chocolate, cotton, wool and linen textiles, municipal tramways, tobacco monopolies, and state industries.

Mass Production

The characteristic of European industry most frequently discussed is that there is less mass production than in America. One reason is that the countries are smaller and the tariff walls prevent the distribution of manufactured articles to a body of consumers large enough to justify mass production. Consumption is also limited by the marked differences in habits of the people in the various countries. A third reason is that wages are low, and therefore the purchasing power of the average family is not sufficient to enable it to buy many of the manufactured articles which in America are purchased in mass. Consumers, particularly in France and England, also demand greater individuality of design than we do.

Nevertheless there is a good deal of mass production in Europe accompanied by strict standardization of design and the use of automatic machines and of moving belts for assembly. Where production of this kind has been successful it has so simplified the management that other manufacturers have looked on it with envy and have frequently installed the equipment for chain production when the volume of sales did not justify it, and as a result the fixed investment became so great that the interest and depreciation swallowed up all the profits. Manufacturers in this situation have often taken the course of dumping their products on the market without profit in order to keep their machines running.

However, in a majority of instances the adaptation of mass or chain production has been extremely profitable. Most of our clients, by standardizing design, reducing the number of styles, and rearranging production to match the tempo of moving belts, have increased output by 25 per cent or more, and have so greatly improved the quality of product and lowered its cost that they have built up domestic sales, and some have opened up foreign markets which were not known to exist.

Turnover of Investment

A slower turnover of investment is another characteristic of European plants. Raw materials are kept in stores much longer than necessary and work moves deliberately through the process of manufacture, which in turn makes it necessary to keep larger quantities of finished goods in stock. This slower time of production requires more investment in proportion to the volume of sales than in the United States.

This difference in tempo between the industries of the two continents has of course a decided influence on resulting profits. European executives are learning that it is more economical to turn over their capital quickly than to secure additional capital on which dividends or interest must be paid.

The American technic of production invariably brings about a swifter flow of material and ideas, and therefore a better turnover of investment. In a Polish plant, for example, where about 3000 workmen are employed, the new methods of management increased production 55 per cent with the same number of workers, very small investments in equipment, and with no changes in executives.

Practice and Theory

Another characteristic of Continental industry is the tendency of the managing staff toward abstract theory, and therefore one of the problems which faces the consultant in organizing a European plant is that of securing a good balance between practical

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In 1917 he resigned from the Remington Company to join Gantt's staff and went to Washington, where he had charge of the latter's work of planning the utilization of ships controlled by the U. S. Shipping Board. In 1919 he started his own consulting practice, which he has since maintained.

During the next six years he investigated the operation of the U. S. Patent Office for Herbert Hoover, then Secretary of Commerce, and was a member of the commission which drew up the plan for the organization of the proposed Federal Department of Public Works. In 1926, as the engineer member of the Kemmerer Finance Commission which stabilized the currency of Poland, he recommended methods for the reorganization of the Polish salt and tobacco monopolies. In 1927, at the request of the Minister of Finance and a group of manufacturers in Poland, he reorganized some of that country's leading industries and since then has extended his services to Germany, France, Switzerland, Czechoslovakia, Rumania, England, and Denmark. He is the author of a number of books, among them being "The Gantt Chart," which has been translated into seven languages.

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and theoretical men. The executives from the superintendent up almost invariably have engineering degrees with good theoretical training behind them, but seldom any actual shop experience in operating machines or processes.

On the other hand, the good shop men are very seldom promoted to positions of responsibility in the management. A workman expects to live and die in the class in which he was born. There is almost no training of good workmen to become foremen, and no classes to fit foremen for higher responsibilities. Evening technical schools are rare and the same is true of correspondence schools. The workman does not expect promotion from the ranks, and does little to fit himself for it.

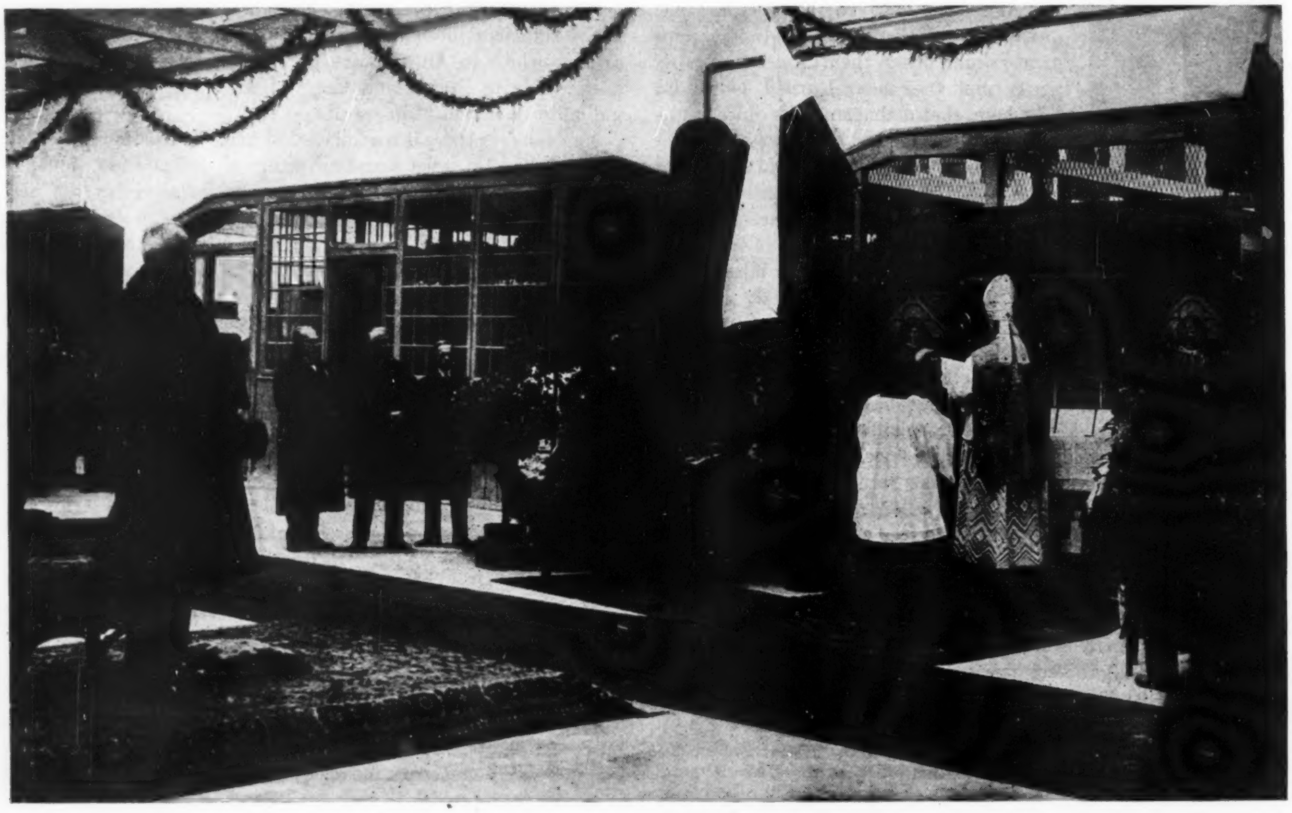
In organizing American shops we do not have much difficulty in securing an even number of technically trained men and those who have been brought up in the shop. By placing them side by side we develop a management which is more sure of itself and quicker to make decisions and take action. In Europe this is more difficult to accomplish because of class distinctions, but fortunately it is becoming easier each year as class lines are relaxed.

In a Polish spinning mill we found a need for more supervision over some of the difficult operations such as doubling and twisting. The superintendent said there was no one who could be assigned as supervisor. On being asked who knew most about this particular operation, he replied without any hesitation by naming one of the operators, but said that she would not do because she was just one of the peasant girls and no one would respect her and follow her orders. However, he consented to give this girl a chance, and a few weeks later told us that the other operators were all willingly obeying her instructions, and that the production of that battery of machines had so far improved in quality and quantity that they were no longer holding back other operations. He then asked us to do the same thing for succeeding operations.

Such promotions from the ranks are not as frequent as they should be, and the reason is not so much that executives oppose it as that it does not occur to any one that it can be done.

Practical Application of Knowledge

Due to the theoretical bias of the average European executive, it is easier to get a matter studied or investigated than it is to get the resulting knowledge introduced into daily practice. In the United States we are more apt at making practical use of what knowledge we acquire, and therefore the results from research are proportionately greater than in Europe, although they have carried on their investigations and experiments for many more years. This fact is realized by the forward-looking managers in Europe, and they are devoting more attention to seeing that the results of research are "introduced into the life," as they express it.



Blessing the New Machinery in a Polish Factory

In a French cotton mill we found girls in the packing department doing all the heavy lifting, while one of the plant engineers for some months had been designing equipment to avoid this fatigue. But the girls went on lifting, while the engineer, enjoying his problem, went on refining point after point of his design. When the engineer was instructed to install the equipment without the final touches, the production of that department increased 45 per cent. Then the executive began to set dates for the completion of all work done on his instructions, and incidentally the girls enjoyed higher wages with a great reduction of fatigue.

Waste of Labor

On the Continent there is extreme economy in the use of materials, which are expensive, and a prodigal waste of the time of workers because wages are low. This is the opposite of the prac-

tice in America and must be kept in mind by the consultant.

In a cellulose-pulp mill in Germany twelve men used to push railway cars from one point to another in the factory yard. Those cars are about one-third the size of American freight cars, but when filled with pulp wood they are quite heavy. One man and an electric truck, which was already in the plant but seldom used, were substituted, and eleven men were transferred to other work which was more important and required more skill. Similar examples could be cited without end.

Due to the lower level of wages it is obvious that many labor-saving devices which are economical in the United States will not pay for themselves in Europe within a reasonable time. This must be kept in mind in appraising the efficiency of a plant, and it is one of the reasons why the production per man is not so great as in America, where a workman has at his command more power-driven tools and transportation equipment.

However, the level of wages in Europe is rising, and we have in almost every case found managers willing to increase wages and to share with the workers the savings resulting from better management.

Respect for Knowledge

The respect for knowledge in Europe is probably greater than in America, where money and influence seem equally important. For this reason the work of the consultant is somewhat easier because he can usually be sure of a sympathetic consideration of his proposals.

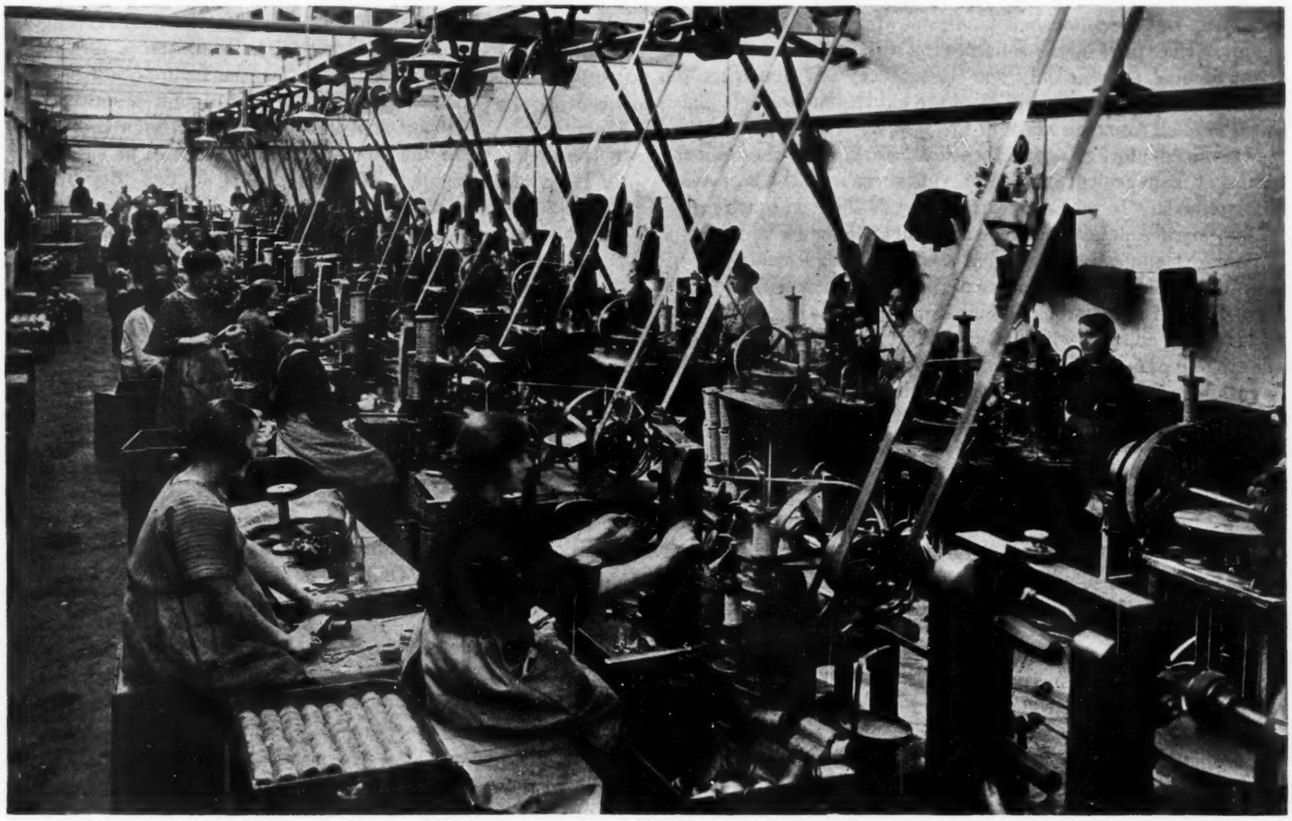
Security for Workers

Europe provides for workmen greater security and continuity of employment than we do in America. A worker cannot be dismissed without notice ranging from two to four weeks, and consequently foremen do not depend on threats of discharge to maintain discipline.

In most of the countries workmen have old-age, sickness, and unemployment pensions administered by the governments. These things help to free the workman from worry about the maintenance and happiness of his family, and enable him to become more proficient in his trade. However, the dole both in Germany and Great Britain has serious disadvantages, and the difficulty of taking it out of politics seems almost insurmountable.

Respect for Authority

European workers have more respect for authority than American, probably because of class lines. A worker will seldom disagree with his superior, and this often makes it difficult to get at the essential facts in regard to many conditions.



Women Workers in Poland

In parts of Germany and in countries east of it, whenever a workman sees an important executive or visitor he takes off his hat, and the older men also bow from the waist. Etiquette requires the executive not merely to touch the brim of his hat, but to lift it.

In France and England this is not the custom, because workmen there are more independent and are not afraid to disagree with their superiors. In England the workmen are backed up by strong organizations, while in France, where workers' organizations are not so strong, the managers have found that their people do not work well in an atmosphere of repression. There is, therefore, more appearance of freedom, and in place of hat lifting and bowing one is more likely to hear a polite "good morning." A French workman may even disagree with his foreman, but he will express himself with the greatest politeness, and also with what we would consider a great many unnecessary words.

In all European countries there are, of course, plants in which

the relations between the owners and the workers are extremely cordial, due to long years of wise and sympathetic consideration of the needs of the workers. As a rule, however, the bow of the workman and the hat lifting of the manager are not accompanied by any relaxation of the facial muscles. One longs for the smile and quick nod which flash through an American shop.

Great Britain and Russia

These characteristics of industrial conditions in Europe apply only partly to Great Britain and not at all to Russia. British shops are in many ways more similar to American than to Continental shops, as England was the cradle of modern industry and we have learned more from her than from other countries.

Russia is, of course, unlike other countries in its fundamental structure, and therefore shop conditions are quite different. For instance, class lines do not separate the workmen from the executives, because there is only one class. Very few managers and engineers have been left over from the old régime, so their places must be filled from the ranks of the workers. There is therefore a determined effort to train exceptional workers for the responsibilities of management, and to provide them with the best available methods. In no European country is there so much eagerness to learn American management methods as in Russia.

The development of managers and of technical engineers appears to be the key to the success of the much-discussed Five-Year Plan. It is a tremendous task to transform an agricultural into an industrial country within such a short time, but the difficulty of changing peasants into machine operators and skilled workmen is nothing compared to developing within such a few years a group of men capable of managing and providing the technical knowledge necessary for industry on so large a scale.

The developing of Russian managers is more difficult than usual due to the absence of rewards as a stimulus to improvement. A manager gets a salary which is frequently not more than 50 per cent in excess of the wages of a skilled workman. This does not enable him to provide for his family a home which will free his mind and energies for his responsible work.

In the early part of this year the heads of the Soviet Government realized that the workers' organizations were interfering too much with the authority of the managers, and they therefore passed new laws giving the managers more authority and at the same time providing prison terms or exile to Siberia for those managers who do not carry out their programs successfully. To an American mind the substitution of the fear motive for the desire for reward and self-improvement cannot develop the best managers. The most satisfactory results from scientific management have been secured where the direction of industry is the most democratic.

Technic of Installation

There are certain obstacles to be overcome in the installation of American methods of management in foreign countries. One of the first to be met by one who does not speak the continental languages is the necessity of working through interpreters. Obviously it requires a little more time to repeat every speech, but, on the other hand, translating has a tendency to make a conversation more precise and to the point. While a paragraph is being interpreted one has a chance to think through the next point to be made.

It is of course necessary in our work for an interpreter to understand thoroughly the various phases of management and the special terminology in both languages. Frequently he has to stop and give a long explanation of a word. For instance, there does not seem to be in French a single word which translates "planning," and he must say: "the preparation, distribution, and routing of work."

In each country it is necessary to study the mentality or psychology of the workmen and executives in order to understand them better, and to know in what particular way any subject should be presented in order to create interest.

We have found that the best results are accomplished when the installation is made by a combination of native and American engineers, one being most proficient in the technic of management and the other knowing the national psychology and habits, as well as the developments in the past which have led up to present conditions. In each of the countries in which we operate, the staff is therefore made up in this way, and the native engineer usually spends twice as many weeks in a plant as the American.

Our consulting work consists mainly of the installation of management methods, that is, adapting methods to a particular situation and staying with it long enough to accomplish practical results. In some cases we analyze the condition of an existing company and recommend a plan for the future conduct of the business. In other cases, after our installation is finished, we supervise the maintenance of the methods and the progress made in the execution of the more important business policies which we have recommended. This service is applied to groups of plants as well as to single companies.

It may be sufficient to outline our technic of installation rather than that of analysis.[2] We handle several clients at a time, spending one week with A, a second with B, a third with C, then returning to A. We have found that an installation is more thorough and therefore followed by better results when we do not split a week between two clients, but devote the entire five days to a single plant.

We work on the assumption that the increase in production, improvement in quality or service, and reductions in cost which are realized during the term of our engagement are less important than those which should follow after we leave. It is therefore necessary for the managing staff to understand these new methods and their principles, and how to get them accepted and used by the entire personnel. One of the most important duties of the consultant is to train some of the members of the clients' staff so that they can continue progress after his engagement is ended.

When we begin our visits a client assigns to us for training one or more men from his staff, relieving them of all other duties so that they can spend their entire time on the new work. These understudies watch every step and soon are able to carry forward many things themselves. We ourselves do not do any repetitive or detail work which can be done by the employees of our clients.

During a typical week's visit to a plant we first go over with our understudy the things they have been doing since our last visit, explaining any points which have not been clear and improving the operation of the method. We then develop the next phase of the installation and begin its actual use. Several things are kept going at the same time, each one being looked after by a different understudy—for example, the installation of planning, storeskeeping, operation studies, costkeeping, and the physical arrangement of the shop. On Thursday a report is dictated outlining as clearly as possible what has been done during the week, attaching copies of all instructions, designs of forms, prints of floor plans, etc., and concluding with the statement of what we recommend to be done before our next visit. This report is presented in two languages, and on Friday afternoon is discussed in detail at a conference of the chief executive of the plant and those members of his staff who are concerned with the execution of the recommendations.

These reports therefore become records of progress or lack of

[2] A more complete description of methods is given in the author's paper entitled "The Technic of Installation of Scientific Management," presented before the International Management Congress in Rome, 1927.

progress, and are extremely useful in securing cooperation and the quick introduction of methods.

After we have spent a short time at a plant and understand the conditions and the personnel, we schedule our own work of installation on a Gantt chart, sometimes a year in advance, showing the various phases of the installation and the weeks we shall be at the plant. For each department in the plant there is a schedule on which a date is set for the beginning and completion of each phase of the installation. As the weeks pass, heavy lines are drawn on the chart to indicate the progress compared with the plan.

Each of the client's understudies has a chart showing the details for which he is responsible. Throughout the installation the time element is emphasized, because one of our major aims is to accelerate the tempo of the entire business, and the promptness with which the executives and staff make decisions and execute instructions determines the tempo of the plant.

Differences in Application of Method

In Europe, as in America, every plant is different, and in installing the so-called mechanisms of management it is quite impossible to impose any rigid set of methods; it is obvious that they must be carefully adapted to the individual business and also to the mentality of the workers and the executive staff.

We have found, however, that in general the mechanisms, such as planning, storeskeeping, salesmen's quotas, and so on, which were first developed in America, apply equally well to conditions on the Continent. Their application is apparently universal, and the changes which need to be made to fit local conditions are not fundamental.

Storeskeeping

In installing Gantt storeskeeping methods, for example, we find that the use of standard bins and boxes, the physical marking of order points, and the routine of ordering, receiving, and issuing materials is practically the same as in the States. There is, to be sure, a greater tendency to require signed receipts for items of small value, but this is not difficult to overcome. In Europe the tendency to save material is sometimes carried too far, for there is too much delay in selling scrap and in disposing of obsolete items which have little chance of ever being used.

The difference is most noticeable in determining "order points" and "quantities to order," which of course depend upon the time required to secure a new supply. Some countries are not self-contained industrially and therefore many items must be imported from other countries, and the delays in going through the customs considerably lengthen the average time of delivery. Even in the more highly industrialized countries the service from suppliers is not nearly so prompt as in the United States. Filling and shipping an order the day it is received is almost unheard of. In those countries in which cartels have eliminated competition, the service is noticeably poorer.

All these things cause the storeskeeping and purchasing departments to allow long periods for deliveries of materials—usually far longer than is necessary even under such conditions. It is necessary to get a purchasing department to adopt a more exacting and aggressive attitude in dealing with their suppliers, but even when the storeskeeping and purchasing departments have done all they can, it is not possible in the average European manufacturing plant to do as large a volume of business on as low an inventory of materials and supplies as it is in America, due to the longer time of delivery.

Plant Layout

There is little difference in the application of the principles of plant layout in Europe, for managers are just as anxious for straight-line production as in the States. Because there are so many old industries, the problem of rearranging the equipment and machines in old buildings is more frequently met than at home. In one plant we had to change the layout of machines in a building which was about 130 years old, and a direct flow of material was secured without breaking down any of the walls.

Planning and Scheduling

Since there is less mass production in Europe, there are fewer shops in which the rate of movement is set by an assembly belt. The need in most cases is for reserved-time scheduling, that is, the type of planning which reserves the time on all machines so that when material is issued from the storesroom it will move at a steady rate through the shop. Wherever installed this type of planning has brought large increases in the volume of production, ranging from 12 to 40 per cent.

Some of the delays in planning are surprising. When a new cupola was to be installed in a foundry we had to reschedule the work to allow a day for the building of an improvised altar on the molding floor, and another day for the priest to bless the new equipment so that it would be safe for use.

Costkeeping

In costkeeping no important alterations in methods are necessary to meet European conditions. We have found that the modern cost methods are more readily accepted than in America because executives are more willing to adopt a method as a whole without wishing to alter details. One client, the director of a municipal tramway company, said that he expected us to provide methods adapted to the peculiar conditions of his plant, and that the members of his staff would give us all the information which we needed, but would not attempt to mix their old methods with the new.

Methods of costing provide the most effective means of improving conditions. In a Polish pulp mill it had been the custom for years to send six men down into a digester to tramp the chips before cooking. At the end of their tramping these men would come up out of the digester on a rope ladder, stripped to the waist, dripping with perspiration, covered with sawdust, and breathing through handkerchiefs which were almost useless in protecting them from the dust in which they worked.

Without any reference to the welfare of the workers, a brief comparison of the cost of time lost in this way with the small gains of tramping quickly brought about the installation of a revolving spreader for the chips which made it unnecessary for any men to go down into the digester.

In the same mill, after the cellulose had been discharged from the digesters, workmen had to go down into the pits and shovel the mass into a chute. Their wooden shoes did not prevent them from getting wet to the knees and the fumes of SO_2 were so strong that they had to come up for air about every ten minutes.

The traditional attitude in such a case is that men are cheap and there are plenty of them. But in order to reduce costs a suction device was installed, and the men no longer had to work under those unhealthy conditions.

Many examples could be cited to show how American methods break through the European attitude toward cheap labor and improve conditions for the workers.

Improvement of Operations

In the study and improvement of processes and operations there is a great deal of inertia to be overcome. Usually the first reaction to a proposed change is that it is impossible, and the second that it is not worth while, because the time saved would be wasted some other way. However, as soon as the interest of the managers is aroused they become eager to make these studies with their own men, and after some training in the tech-

nic these men succeed in bringing about marked improvements.

The men chosen for this work sometimes have technical training, and in other cases are workmen who have developed exceptional skill. They are so close to the workers that they are able to stimulate creative ideas in the workers' minds, and as a result, the latter take much more interest and pride in undertaking and mastering new things.

Incentive Payments

The idea of incentive payments is not new in Europe, and in the majority of plants in the author's experience, piece rates are in common practice. The rates have not usually been set with sufficient care, nor has there been any attempt to determine the best method of doing the operation; therefore the rates are not successful in securing uniformly high production.

In applying a bonus system there are no unusual difficulties, except that simplicity is even more imperative than in the States because workmen are not so well educated. In Russia, where the equality of workmen is emphasized, piece rates in several shops were said to be a recent development.

Sales and Distribution

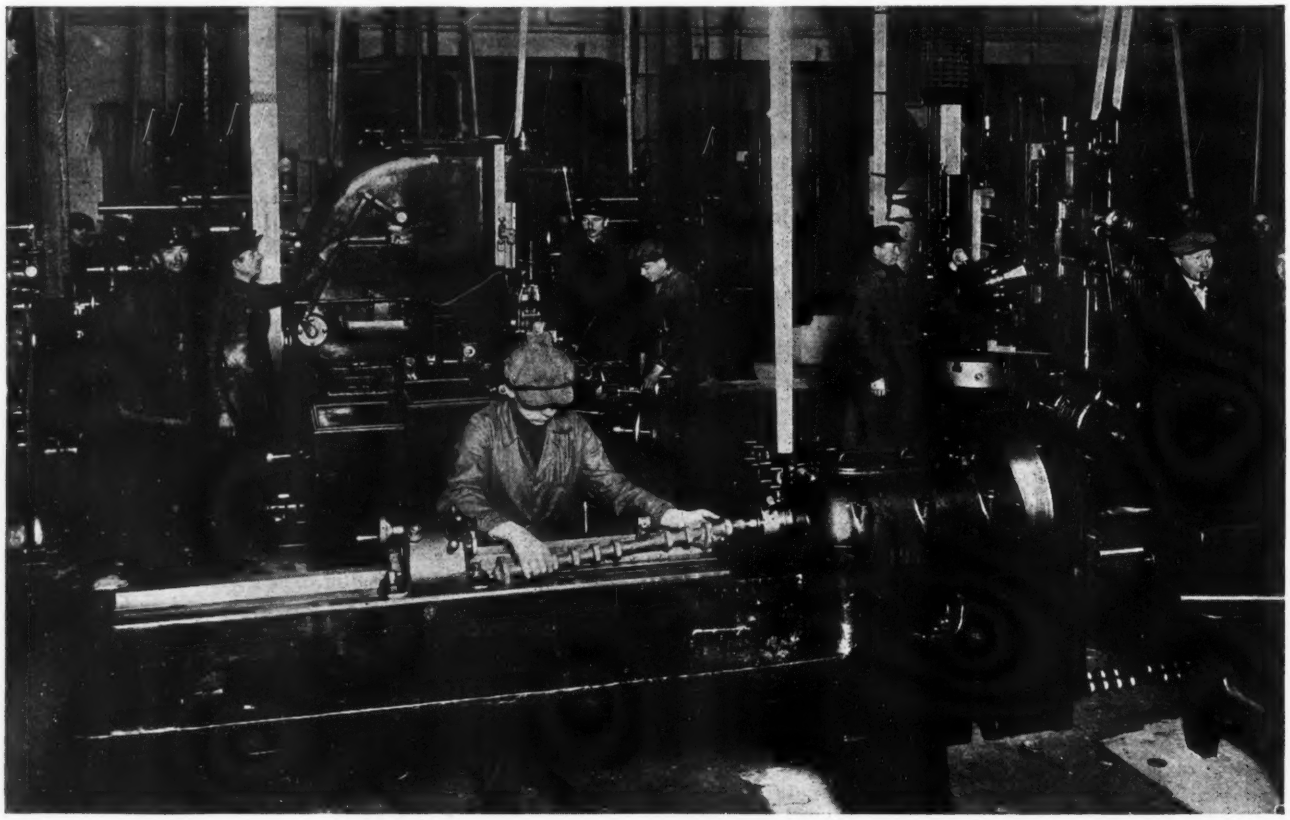
In spite of the wide acceptance of American methods of production, Europe has not yet awakened to the importance of distribution. The need for market analyses is even greater than in America, because there are more pronounced differences in the customs and buying habits of the people in the various sections of European countries.

In Russia there is no problem of selling because there is almost no private trading, but distribution is extremely difficult through such an immense territory.

Budgeting—Executive Control

Within the last few years Europe has taken a keen interest in the matter of financial budgeting. This was shown by the remarkably successful Budgetary Conference held in Geneva in July of this year under the auspices of the International Management Institute.

Even in plants where expenditures are closely watched, as they usually are on the Continent, it has been surprising to see how expenses have been reduced by careful planning and the fixing of responsibility which the budgets have brought about. Accountants have welcomed them because they do so much to clarify the relations between them and the executives.



Modern Machinery in a Polish Plant

Recent developments in methods of executive direction have attracted the attention of forward-looking executives in Europe, who are eager to learn the most dependable technic of securing cooperation and of directing instead of following the progress of a business.

It is obvious that one of the principal duties of a chief executive is to prepare his company to meet whatever happens in the future, and this directs his attention to forecasting conditions in general business as well as in the specific business in which he is engaged. But European statistics needed to form a basis for forecasts are far from complete. The various governments keep records of imports, exports, bank clearings, and other matters which pass through their hands, and they publish figures which are usually prompt and accurate. Some Chambers of Commerce also provide valuable data, but the information about specific branches of industry, which in this country is secured through trade associations or the Department of Commerce, is rather meager. For this reason planning for the future of a specific business is more difficult in Europe.

One client owning plants in three countries and distributing his products in six countries, prepared forecasts for all those countries, and in spite of the incompleteness of the data he was able to secure fairly reliable forecasts of changes in business conditions.

Results

In order to illustrate the results obtained, other than in increased production or in savings, by a typical installation, part of an address delivered before the Engineers' Association of Warsaw by Mr. J. Zaporksi, Technical Director of Lilpop, Rau & Loewenstein, a company with 3000 workmen which builds railway passenger and freight cars, is given below. Mr. Zaporski says:[3]

One of the features of the new method as a whole and in detail is a considerable clearness and a simplification of work in all its phases. The installation was begun from the last phase of manufacture, the erecting shop, and this has brought about its penetration to all our needs which actually derive from that shop and are dictated by it.

The benefits obtained are general. The production has been entirely mastered, while the normal management duties connected with this production have been mechanized, that is, brought to quite determined forms and phases which put clearly defined responsibilities on the shoulders of each of the executives, and, in case of divergences from the normal flow, allow the fixing of responsibility for each of them.

By this mechanization of every-day duties, the initiative of managers and subordinates has in no way been limited; on the contrary, executives have today more time to study the improvement of production, since most of their every-day troubles have been taken off their shoulders and placed on those of less important men by means of planning.

A proper and accurately defined division of responsibilities between members of the management and employees and a strict control of the timely execution of the duties of each of them obliges them to bring to attention all difficulties which they meet in their work, which causes an automatic improvement of the whole organization.

In closing I wish to express some of the general impressions on the work done.

The entire personnel of our plant has become deeply interested in the new organization. It has penetrated into every part of the factory life, leaving everywhere its mark. Naturally there were some difficulties which, however, were easily overcome and we can say that the better a man understood the spirit of the methods and the more deeply he penetrated into those ideas, the more eager he became to follow them and the better results he obtained.

The organization breaks no one's individuality and harms no one; on the contrary, it develops personal efficiency, representing his progress in units which are easy to measure. Clear-cut duties and responsibilities allow each member of the organization, irrespective of the work he performs, to show his own accomplishment.

All unnecessary ballast, which appeared to be useful but in reality obscured the clearness of things, was removed. A sound foundation of management was created, that is, a plan thoroughly thought out and made in advance for all work. The principles of fair play are apparent everywhere; work is made easier, conditions of work are improved, and earnings are increased.

Group of Workmen in a Polish Factory

Progress of Management in Europe

In every large European country there is a national organization for the advancement of the science of management. These groups have received financial support from their respective governments, which have been anxious to obtain the advantages of good management in their struggle for export markets. The work of collecting information and broadcasting it to technicians, managers, and the public at large, as well as the translation of books and papers on management subjects, has been done by these national groups.

The International Management Institute in Geneva has shouldered the difficult task of coordinating the work of these

[3] The complete address, which will be published later in Transactions as an appendix to the paper, illustrates the methods installed and the attitude of an executive toward them.

national organizations and stimulating the free interchange of information among them and the American groups.

Four international management congresses have been held in Europe, presided over by such statesmen as Mazaryk, Mussolini, and Tardieu, and attended by thousands of delegates who have gone back to their homes in every industrial country with an added realization of the importance of management.[4]

At the present time there is in Europe a more general understanding of the fact that conditions are changing. Industrialists are realizing that the acceleration of change which has taken place since the Great War cannot be expected to slow down. They are therefore reorganizing their businesses, not only to fit changed conditions but to anticipate further changes. They are seeking more flexible methods, more effective planning for the future, running comparisons of what actually happens with those plans, and are training executives to see the tendencies thus revealed and take the action necessary to get the best results from those changes.

Technological Unemployment

In Europe more consideration is being given to technological unemployment than here at home. Labor is less mobile there because it is more attached to the land, and also because jobs are more difficult to find and therefore losing one's position is much more serious than here.

In many cases the head of a business gives his personal attention to providing positions for the workers who are displaced by labor-saving machines or processes. He does this in a variety of ways: by passing a part of the savings due to the new machine on to consumers in the form of lower prices in order to increase the volume of sales; by improving quality; by extending the service to consumers; by more intensive advertising; by taking on additional lines of manufacture, and sometimes by building entirely new plants to absorb the workers released by the introduction of new equipment or methods.

In those countries where there is a good deal of unemployment due to economic conditions, the introduction of better methods is particularly difficult, but it must go on because the high costs of production and ineffective sales methods have been largely responsible for the gradual decrease of business and the consequent increase of unemployment.

Management Helps the Worker

The introduction of the new management into European plants has almost invariably brought about better working conditions, higher wages, and steadier employment, just as it has in America. It is fortunate that there is on both continents a growing recognition of the worker. It is particularly easy to see this in some of the older countries where there are so many reminders of the early stages of the industrial era, when a worker's time, health, and even life itself were held so cheap. The long hours he worked, his miserable wages, the inhuman punishments he suffered for any infringement of the rules, and the conditions under which women and children were employed, seem incredible today.

The general welfare and prosperity of a nation appear to go hand in hand with the better appreciation of the worker. A realization of his importance as a consumer has done much to bring him better wages and a higher standard of living, which in turn has helped general prosperity. His influence as a shareholder is also beginning to be felt, and in many plants on both continents he has a good deal to say about management policies.

In Russia the satisfaction of the worker is regarded as one of the prime objects of industry. This year, when asked by the Soviet Institute of Management Technic to develop and install management methods in an entire branch of industry, the author was requested to keep the following objects in mind:

To provide safe and healthy conditions for the worker;

To remove from his path the obstacle which prevented him from doing good work;

To enable the worker to understand his part in industry and to have maximum freedom for self-expression.

This is of course a statement of aims and these conditions have not yet been introduced into industry; however, when her plans have been carried further, it seems quite possible that Russia may make a major contribution to the welfare of mankind by developing the worker and improving his position in industry, and, even though we may not agree with her political dogmas, the Western world should not hesitate to learn as much as it can from this gigantic experiment.

One of the greatest services the management engineer can render is to make existing knowledge and method available so that constructive minds will not need to go over ground which has already been covered: to simplify the routine so that it will require a minimum of time, and in other ways to free the creative energies of executives and workers.

The pioneering work of applying science to management has been done, and the mechanisms or technic of management have been developed. Much will be done in the future to improve this technic and extend its application to new fields, but the task of the management engineer now is to place this science of management at the disposal of every part of industry and then to concentrate his energies on developing the individuals and stimulating their creative brains.

Conclusion

When we read the reports of disarmament conferences, hear the threats and counter threats of government spokesmen, and watch the frantic building of tariff walls, the picture is discouraging.

The workman on the frame of a fifty-story skyscraper knows that his safety depends on his ability to focus his eyes and concentrate his mind on the steel beam immediately before him. It is the same with the engineer—he does not allow himself to be distracted by other things or to worry about the complexity of the maze about him. He takes one thing at a time and organizes that to the best of his ability, and then goes on to the next, building carefully, even if the extent of his work seems small.

The engineer is busy with his plans and charts, his records and forecasts, but nevertheless he is sensitive to what is going on around him and the changes which management is bringing about. He sees it provide machines to take the burdens from man's back, allowing him to use his mind rather than his animal strength, and to free himself from poverty. He sees industry teaching men to understand more clearly their aims and to cooperate in reaching those objectives; fair play becoming a daily habit rather than a text for a sermon; the authority of leadership going to those who are capable of leading without regard to class lines.

The engineer sees executives imparting to others the knowledge which they formerly kept entirely to themselves, and whole groups of industries overcoming their suspicions and exchanging information for mutual benefit. He sees commercial agreements being made which disregard boundaries and forget the fears and hatreds of the past. He hears the shouting of warriors and idealists exhorting people to follow them to freedom and happiness, but as he goes on with his work, he watches the machine age and the new management breaking down barriers, healing old wounds, wiping out poverty, and giving men more freedom to develop themselves and to prepare the next generation to lift higher the torch of progress.

[4] In order to give a more complete picture of the progress of management in Europe, brief reports from leading industrialists in nine countries, summarizing what has taken place there and pointing out present tendencies, will be published later in Transactions as appendixes to the paper.

Crane Lubrication

By EUSTIS H. THOMPSON,[1] BALTIMORE, MD.

A FEW years ago the author was given charge of the crane equipment of the Baltimore Copper Smelting & Rolling Company. At that time the Baltimore Company had thirty-seven bridge cranes, principally of 10 tons capacity, six monorails, two of which were just going into operation, six furnace-charging machines, and about a dozen hoists.

Within about three years, one monorail and six bridge cranes were added, and shortly after, as a result of some changes in ownership, four bridge and two monorail cranes were removed from the group. Although the maintenance of the remaining crane equipment was carried on under one supervision, some of it came under the ownership of the Revere Copper and Brass Corporation. About one-half of the bridge cranes were closely interchangeable, being of the same capacity and make.

Four different makes were represented altogether, ranging from a recent product of one of the largest manufacturers to a few antiquated cranes, one of which was built before its maker had adopted serial numbers.

It is a significant fact that the oldest cranes have not generally been scrapped and replaced by newer and improved machines. The general policy has been to incorporate inexpensive changes or improvements so that the present demands can be met without appreciable delays, and at a reasonable maintenance cost.

One of the oldest cranes charges, or assists in charging, two of the largest furnaces. Its capacity is five tons, and its average load four to five tons. Other charging cranes of more recent design are of twice this capacity, but handle ordinarily four to five tons at a lift, which is practically one-half load.

Crane Service

After the war came a period of increased production. Repairs had been restricted previously to the lowest reasonable point, so that the increased crane activity developed many weaknesses. In fact, delays were so much in evidence that on one occasion, when the entire equipment ran a week without once delaying production, it was felt that a record had been made.

It soon became apparent that lubrication trouble was responsible for a large amount of delay and maintenance expense. For instance, an important crane went out of commission, shutting down a department for half a day on account of a bridge journal running dry. Armature changes were similarly frequent, and repairs high. Most armatures turned out to be oil-soaked.

The most frequent direct complaint was lack of lubrication. The crane operators were too busy, ignorant, or lazy in some instances, to lubricate properly. Repair men sometimes failed to lubricate their work properly. The men on the floor frequently called for a lift when an operator was on top of the crane oiling or greasing it. Crane operators sometimes alleged that floor men watched for such opportunities in order to display industry of a questionable and malicious nature.

How Crane Lubrication Was Obtained

One of the first things done was to get the elementary matter of lubricating the cranes on a more dependable basis.

It was not considered practicable for one or two men to undertake the work. Distances were comparatively great, as many departments were a quarter of a mile or more from each other. Also certain cranes were so busy that it was difficult to get a lubricating period at the same time each day or week.

On the other hand, the regular crane operators were best able to apply the lubricants as the demands of production allowed. This, however, required the interest and cooperation of their foremen who were engaged in production work.

The department heads in locations where the most trouble occurred were each asked to appoint a man to visit the cranes personally once a week to see if the operators were lubricating them properly. The responsibility for a bearing failure could then be immediately placed on this inspector, and it was then to the best interest of the department head to find the delinquent operator and correct the error of his ways.

It required a year or more to get this plan adopted completely. The departments which first introduced it went through six months with clean records; those which did not had quite different results.

At the end of each six months, the situation throughout the plant was reviewed by means of letters, copies of which were sent not only to the inspectors but also to the foremen and higher executives. Each time the record improved, and each time a better showing was made the goal for the next period.

Finally some of the departments ran two or three years without losing a bearing, and since then the entire equipment has operated with a loss of but two or three bearings a year from careless lubrication.

Armature losses from oil were largely prevented, and crane delays and expenses were reduced accordingly. Maintenance work was finally executed by one repair crew for both mechanical and electrical work for the majority of the cranes. All work now is the result of frequent inspections. Controllers are repaired at frequent intervals, while other work is saved as far as possible for a scheduled repair day that comes once in two months.

Spare armatures equipped with fitted bearings are available for use in case of armature failures.

Crane spare parts, including lubricating and oil-tightening devices, are kept on hand by the storekeeper in accordance with a carefully worked-out list, and are ordered by means of a blue-printed specification.

With this description as a background, the general crane lubrication will be dealt with, and then some special problems.

General Lubrication

Stock Lubricants. For the various kinds of machines throughout the casting houses, refineries, rolling mills, etc., certain types of lubricants are carried in stock.

For instance, the light, medium, and heavy types of lubricating

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Contributed by the Petroleum Division for presentation at the Annual Meeting, New York, N. Y., Dec. 1 to 5, 1930, of The American Society of Mechanical Engineers.

oil fit any ordinary mill or shop lubricating condition. Special oils, such as for turbines and compressors, are not here considered.

Besides the service to be met, the oils are selected to meet market conditions. Generally speaking, oils are purchased on the basis of giving the required satisfaction at the lowest overall cost.

Standard specifications are provided for lubricating oils, with the requirement of satisfaction in service. In some cases detailed lists of lubricants required for various machines have been issued. Specifications of three mill lubricating oils are as follows:

	Saybolt viscosity	Baumé	Flash	Fire
Light mill oil	230 at 100° F.	25.9	405	465
Medium mill oil	550 at 100° F.	20	375	425
Heavy mill oil[1]	144 at 210° F.	25.2	550	630

[1] Actually cylinder oil containing 5 per cent of tallow.

Three lubricating greases are used:

(1) No. 3 cup grease, solidifying at 185 deg. fahr.; complying with U.S.G. Standard Specification 2C, Technical Paper 323A. (Department of the Interior, Bureau of Mines.)

(2) Cable grease, solidifying at 110 deg. fahr. and consisting essentially of a heavy, dark-body oil containing 13 per cent of magnesium carbonate and less than 1 per cent of graphite, being a distillation residue not refined, similar to black oil. The magnesium carbonate assists operation at a higher temperature by preventing thinning out to some extent.

(3) Pressure system grease, solidifying at 80 deg. fahr. This is a sodium soap grease containing cylinder-oil stock, used for grease systems and roller bearings.

Greases for roll necks are not here included.

Gear Coatings. Two sticky-type gear coatings are used. These are compounds of asphaltum and pine oil. No. 1 solidifies at 80 deg. fahr., and No. 2 at 160 deg. fahr.

Choice of Lubricants for Cranes

Oils. At one time practically the entire crane equipment was lubricated with light mill oil. This is a paraffin type of lubricant and met with most diverse requirements, such as lubricating axles on trucks which were used in baking ovens at 400 deg. fahr., as well as the bearings of electrical machinery where the original filling of oil with a little occasional make-up has lasted sometimes as long as ten years. This is the least expensive of the three oils and used by far in the greatest quantity.

Later on the crane equipment was changed over to the medium-type oil, which is a naphthene type. The reasons for this change were as follows:

1 Outdoor cranes sometimes gave trouble due to oil being congealed in the bearings during cold weather. The naphthene oil flows as a liquid at a much lower temperature (0 deg. fahr.) than the paraffin type (35 deg. fahr.).

2 Many cranes operate in close proximity to furnaces. The light paraffin oil thins out to an undersiable extent in the warm bearings. Operators frequently mix heavy or cylinder oil in the bearings during the summer time.

The heavier medium oil gave a greater body at the operating bearing temperature in hot weather than light mill oil.

3 Many bearings leaked oil excessively, making the least expensive oil desirable. These, however, have been oil-tightened so that the cost of operation with the higher-priced medium oil is justified.

4 One type of oil can be used for all seasons and all conditions, so that it is not necessary to supervise the lubricating so closely to make sure that cylinder oil is not added in the winter, etc.

5 The heavier body of the medium oil is of special benefit in starting up and quick-reversing. It protects the babbitt lining from rubbing and shock much better than light oil.

Table 1 gives results of tests of two matched oils, one of naphthene base and one of a paraffin base. In this particular instance, the naphthene oil costs less than half that of the paraffin.

TABLE 1—TESTS OF TWO MATCHED OILS

	Paraffin oil	Naphthene oil
Appearance by transmitted light	Very dark red	Dark red
Odor	Straight mineral	Straight mineral
Water	Zero	Zero
Gravity, Baumé, A.P.I.	24.7	22
Corresponding specific gravity	0.9050	0.9211
Flash test, deg. fahr.	415	360
Fire test, deg. fahr.	470	410
Color	8 (M.P.A.)	7 (M.P.A.)
Viscosity univ. at 100 deg. fahr.	514	500
Viscosity univ. at 150 deg. fahr.	145	144
Viscosity univ. at 210 deg. fahr.	65	55
Carbon residue, per cent	0.92	0.50
Cold test, deg. fahr.	20	15

Some of the difference between paraffin- and naphthene-type oils are listed in Table 2. Further information can be obtained from the volume "American Lubricants," by L. B. Lockhart, also "Industrial Oil Engineering," by J. B. Battle.

TABLE 2 PARAFFIN VS. NAPHTHENE OILS

(Qualities compared at the same viscosity)

Type of oil	Paraffin	Naphthene
Formula type	Chain compound $CH_3CH_2CH_2CH_2CH_3$ 5 C 12 H More hydrogen	Cyclic compound $CH_2CH_2CH_2CH_2CH_2$ 5 C 10 H Less hydrogen
Relative weight of unit volume at a given viscosity	Lighter	Heavier
Bloom (color by refracted light or reflection)	Green	Blue
Flash and fire points	High	Lower
How present	All kinds	Medium and light oils of around 500 viscosity, and below but not in cylinder oils
Relative cold test and pour point	Higher	Lower

For equal viscosities at 100 deg. fahr. the naphthene oil will have less viscosity at higher temperatures, such as 210 deg. fahr., than the paraffin type.

Where one oil is substituted for another at higher-temperature service, the viscosities at the operating temperature should be checked.

Grease. Cup grease needs no special comment. Old cranes are lubricated throughout with grease cups, while the newer types have oil-ring motor bearings and journals packed with wool waste and oil.

Grease cups are preferred to pressure guns or grease pressure systems for the following reasons:

1 An operator must be in close proximity to the bearing when feeding a grease cup. Heating or cutting of the bearing is more apt to be observed than when a gun or centrally located grease pump is used.

2 It is ordinarily easy to tell from the feel of a grease cup whether it is stopped up or feeding. This is more difficult with a gun, and not ordinarily possible in a central system.

3 It appears more convenient to fill the top of each grease cup from a bucket of grease than to apply a gun to a bearing, or to use gun-filled grease cups.

4 Pumps and grease systems may possibly get out of order. The grease cups used at present give no serious trouble from this cause.

5 Much trouble has been experienced from grease pumps being removed or stolen by operators due probably to the fact that automobiles are fitted for this form of grease application.

6 A grease cup in a place hard to reach is more convenient than a gun application. This point, however, is open to considerable argument.

7 Grease systems mean small pipes running to all bearings. This involves greater trouble when doing repair work and there is a greater tendency for dirt to be introduced when the pipes are disconnected. Such pipes are easily damaged by repair men or operators.

8 Last, but not least, grease cups are the cheapest and simplest of all such devices.

The author is well aware, however, that grease guns and pressure systems are utilized advantageously in many plants throughout the country for crane equipment.

Many of the foregoing statements would not be true for different operating conditions, while others represent personal preferences rather than the results of a generally accepted viewpoint.

Grease-Cup Troubles

The principal trouble with grease cups in the Baltimore company's plant have been:

1 Caps being lost due to vibration or wilfully thrown away by the operator.

2 Caps being cross-threaded when filled.

3 Loosening of cups due to vibration.

4 Cups being too small for convenient use.

Losing of caps was prevented principally by using chains to hold them to the stems or other supports. A little tightening of the supervision induced the operators to treat the grease cup with respect. Cross-threading has been practically eliminated by adopting a larger type of grease cup with a coarse thread.

After trying many types of grease cups, one was finally standardized which turned out to be about the lowest in cost and simplest in construction. It is a two-ounce cup.

Gear Lubrication

In general the cranes are equipped with hardened and heat-treated gears, and in most cases ordinary cup grease gives a satisfactory life of the gear teeth, such as ten or twenty years. Cup grease is always available on the crane, and therefore naturally becomes the gear lubricant.

Exceptions to this are one or two cranes where grease from the bridge-wheel drive gears tends to fall on the track and make it slippery. This in turn causes the cranes which have a short bridge to slew around and bind on the rails when stopped quickly.

A sticky type of gear lubricant such as No. 1 can be applied in such cases satisfactorily.

It is believed that the sticky type of lubricant tends to give a longer gear life. This has been illustrated on roll-train reduction gears and pinion stands.

It is evident that gear teeth tend to squeeze out lubrication film. The film is not positively confined as in a sleeve bearing. This is especially so at slow speeds.

Gears operate theoretically on a line contact so that the area of contact is exceedingly small and the unit pressure on lubricants is correspondingly high. In addition to this, the alignment is seldom good enough to insure true line contact, so that shocks and jars must exaggerate conditions.

This sticky type of gear coating produces a film of high friction, but of immensely more resistant body. There are also lubricants on the market which combine the two qualities of heavy body and oiliness. It would be difficult from a practical viewpoint to use a sticky gear coating in cranes, as it would doubtless reach bearings or other places where it would be objectionable. In some places the gear speed is too high for this material.

Special Lubricating Problems

It is not easy as a rule to obtain the consent for spending money for changes and improvements. Development work often requires a number of trials in order to find a solution which brings all factors desired under control at the lowest reasonable cost for installation and maintenance.

However, it is perhaps true elsewhere as well as at this plant that improvements which can be obtained for little or no cost, practically speaking, are more readily accepted. This attitude has resulted in interesting solutions on several occasions.

Case No. 1—Oil Leakage on Monorail Hoist Armature. Several monorail cranes of obsolete design gave much trouble from losing hoist armatures due to oil leakage. The worst offender on one occasion required a hoist-armature change each month for six months.

A mechanical load brake operating in a bath of oil churned the latter up, throwing oil along the hoist-armature shaft into the hoist armature. This was remedied by placing a diaphragm and an oil thrower between the oil cellar and the commutator, although there was very little room to install these devices. (See Fig. 1.) The result was that armature life was extended to about six months.

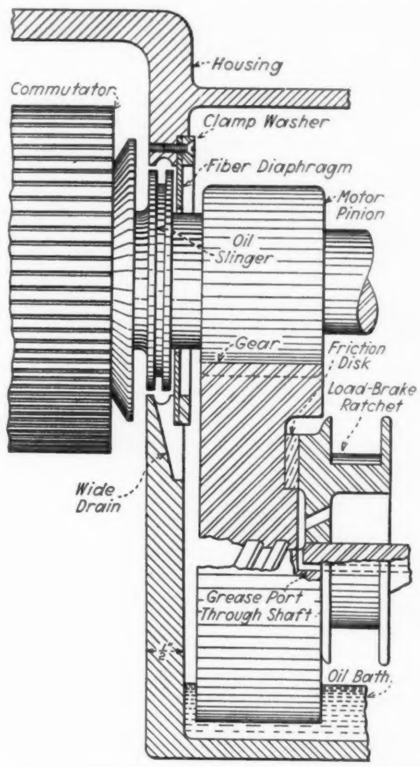

FIG. 1 CHANGING MECHANICAL LOAD BRAKE FROM OIL TO GREASE LUBRICATION

An ideal way of overcoming this trouble would be to eliminate the mechanical load brake, and rig up an electric brake and dynamic braking system instead. Contrasted with the cost of repairing armatures, this would appear to require a comparatively gigantic investment.

After trying to work out some solution that could be introduced almost without cost, a change in mechanical brake lubrication from oil to grease suggested itself.

The load-brake shaft was then equipped with a grease cup and drilled so that grease would be conducted to the friction surfaces. The oil-tightening device was practically 100 per cent effective in keeping out the grease. A hole was placed in the load-brake casing so that grease would not accumulate above a certain amount, as otherwise it would escape through this hole. All monorails have thus been changed.

As a result, the armatures now operate in a bone-dry condition; and this oil trouble has been entirely eliminated.

Case No. 2—Oil-Tightening Motor Bearings. Oil leakage was a considerable factor in the maintenance cost of a certain type of motor, of which there were a large number in the plant. Oil leakage was caused by the following conditions:

1 Catch grooves for oil at the ends of the bearings were of various designs, and frequently drained in an improper manner.

2 The babbitt lining used when rebabbitting the bearings often contained considerable lead, and wore out very fast.

3 The operators in filling the bearings lifted the caps on top, and poured oil in large quantities. The regular overflows would not carry the excess oil off quickly enough, so that it ran inside of the motor housings.

4 Excessive wear, and occasionally loss of the bearings, was sometimes caused by the oil rings being thrown above the shaft, and catching on a projection in the oil cellar.

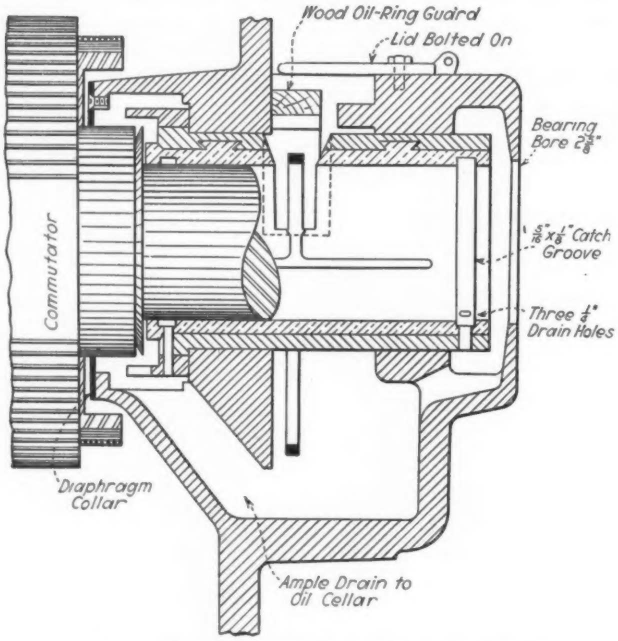

FIG. 2 OIL TIGHTENING OF MOTOR BEARINGS

CHANGES TO PREVENT OIL THROWING

Several efforts were made to overcome these conditions, the final solutions being as follows:

1 The bearings were standardized with generous catch grooves extending around at each end, and drained by holes of ample area.

2 A tin babbitt of high grade and containing no lead (tin 88, antimony 7, copper 5) was substituted for the original type of lining. A section of this bearing is shown in Fig. 2.

3 The lids on the tops of the bearings were fastened down by bolts so that the operators could not easily lift them when oiling up. Oil was introduced through the overflow cup in the lower part of the bearing, so that the oil level could not be too high.

4 A wooden guard was installed over the oil ring, so that it could not rise high enough to catch.

5 It was found in many motor heads that the oil leaking out of the inside end of the bearing did not run back quickly enough to the oil cellar. Instead it tended to leak off inside the motor. The motor heads were changed so as to supply sufficient drainage.

6 A diaphragm or washer fitting the shaft closely to prevent oil leakage along the shaft was a feature of later cranes purchased. This was installed also on the older cranes.

Case No. 3—Eliminating Trouble on Hoist-Motor Brakes. A certain type of crane, now obsolete with the manufacturer, was fitted with a cone-type brake on the hoist-motor shaft. It was the experience for many years that the motor shafts became easily sprung and sometimes broken. In order to prevent the cones from falling down and causing injury when shafts broke, guards were placed on the motor heads to catch the cones.

The cone contained wooden blocks that engaged the stationary steel clutch. A solenoid opened the brake when current was applied to the motor, and closed it quickly when the current was interrupted or turned off.

Since the motor operated at about 1500 r.p.m. and the dry wooden blocks tended to seize the clutch, tremendous strains were introduced, and the wear on various mechanical parts was severe. The necessity for frequent adjustment and renewal of parts made this brake a highly objectionable feature.

The usual method of overcoming such trouble was to eliminate this type of motor brake by substituting the usual jaw-type brake together with dynamic braking, and eliminating the mechanical brake which carried the hoist load.

The mechanical brake occasionally got out of adjustment, leaving some of the load to be taken up by the motor brake, and greatly increasing the difficulties. The motor brake was designed only to stop the motor.

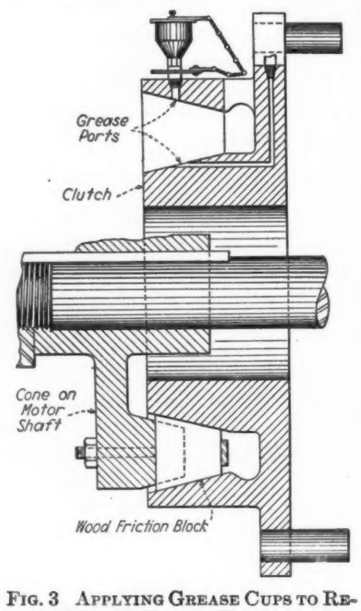

FIG. 3 APPLYING GREASE CUPS TO REDUCE MOTOR BRAKE FAILURES AND COSTS

The problem was attacked with the idea of not spending any money, practically speaking, for a remedy. In other words, the idea of using a dynamic braking system was discarded while looking around for other solutions.

It was known that grease placed on the wooden friction blocks stabilized operation for a while. It therefore seemed probable that the seizing action of the dry blocks was something that might be overcome by a permanent type of lubrication.

The stationary clutch was therefore drilled and fitted with a grease cup. This proved to be an improvement, but it was not sufficient. (See Fig. 3.)

It was then found that only one surface of the clutch received lubrication, while the companion surface of the clutch which made contact with the inside surface of the wooden friction blocks still set up undue strains.

A second grease cup was therefore installed to take care of this surface. The result equaled expectations, if it did not exceed them. For practical purposes the continual adjustment is no longer necessary, the use of wooden friction blocks has been reduced about 60 per cent, and springing of shafts practically eliminated.

The cranemen feed grease in one or more times a day. Any undue heating tends to melt grease in the pipes and supply lubrication. The drying action of the wooden plugs is checked so that they tend to remain tight in the clamps.

Destruction Test of an Electrically Welded Superheater Drum

By O. L. COX,[1] WASHINGTON, D. C.

THE test about to be described was made on a drum similar to the drums being manufactured[2] for use on one of the light cruisers for the U. S. Navy.[3]

The test drum was constructed of the same material and to the same dimensions as the actual drums, except that only one steam nozzle was installed and only 108 tube holes were drilled. The drum ready for test is shown in Fig. 1, with the tube holes plugged. It is approximately 18 in. in inside diameter, 8 ft. 4 in. long, and has a wall thickness of 1/2 in. except for the tube sheet, which is 1 1/4 in. thick. The head is elliptical and 5/8 in. thick. There are three longitudinal welds: the top head, bottom flange, and steam nozzles are welded on with proper reinforcement to maintain uniform strength. (See Fig. 8.)

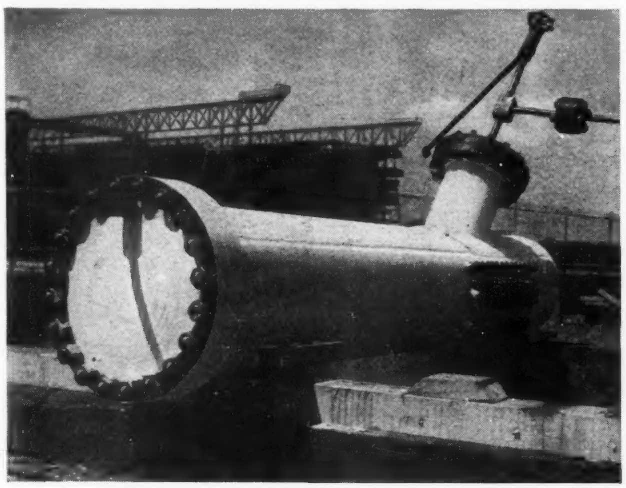

Fig. 1 Drum Set Up for Test

The method of plugging the 1 1/4-in. tube holes is clearly shown in Fig. 2. These holes were located adjacent to the steam nozzle.

The material used was Class "B" boiler plate with a minimum ultimate strength of 55,000 lb. per sq. in.; minimum yield point one-half the ultimate strength, and minimum elongation in 2 in. approximately 25 per cent. The average ultimate strength was about 57,500 lb. per sq. in., and the working pressure of drum, 300 lb. per sq. in. gage.

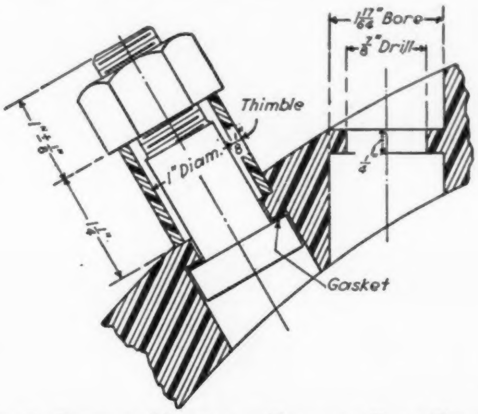

Fig. 2 Showing Method of Plugging Tube Holes

The drum was given a thorough coating of lime wash and the steam nozzle fitted with a blank flange. Connections were made to this nozzle for water supply and an air vent. The connection to the pressure gage was taken off the lower flange bonnet.

The following table gives the various hydrostatic pressures to which the drum was subjected. After each test the pressure was reduced and a careful inspection made.

Pressure applied, lb. per sq. in.	Remarks
500	O.K.
850	Tightened up on flange bolts on steam nozzle
850	
1040	Tightened up tube-hole plugs
1250	
1500	
1675	Slight cracking of lime wash on 1/2-in. plate, indicating yield point
1700	General cracking of lime wash. See Fig. 3
2350	
2565	Gasket in steam nozzle failed. Replaced
2450	Gasket in steam nozzle failed again. Flange badly warped Replaced blank flange by welding in plug
2750	Two studs in lower flange failed. One replaced, C-clamps put on other
2770	Failure in ligament between two tube holes. See Figs. 4 and 5.

Fig. 4 shows clearly the yielding in the tube sheet and the deformation of the tube holes. The bulging of the tube sheet reached a maximum of 7/8 in.

The calculated stress at failure in the ligament is approximately 66,000 lb. per sq. in., and in the 1/2-in. plate 49,900 lb. per sq. in. when the ligament failed. The calculated stress at yielding in the 1/2-in. plate is approximately 29,700 lb. per sq. in.

The uniform strength of the drum is well illustrated in Fig. 3, which shows general cracking of the lime wash throughout the length of the drum, and particularly on the steam nozzle and its reinforcing pad.

[1] Captain, U.S.N. Bureau of Engineering, Navy Department. Captain Cox was born at Rix Mills, Ohio, October 16, 1883. He entered the U. S. Naval Academy in September, 1901, from which he was graduated in 1905. After four years service at sea he took a two-year post-graduate course in engineering at the Naval Academy, which he completed in 1911. Since that time he has successively been chief engineer, U.S.S. *Salem*, 1911–1912; assistant in design division, Bureau of Engineering 1912–1915; assistant inspector of machinery, Fore River Shipbuilding Co., Fore River, Mass., 1915–1916; assistant engineer and chief engineer, U.S.S. *Nevada*, 1916–1918; engineer officer, Navy Yard, Charleston, S. C., 1918–1921; inspector of machinery, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., 1921–1922; assistant in design division, Bureau of Engineering 1922–1925; and division and fleet engineer, Battle Fleet, 1925–1927. He has been head of the design division, Bureau of Engineering, since April, 1927.

[2] Manufactured by A. O. Smith Corporation, Milwaukee, Wis.

[3] The Bureau of Engineering of the Navy Department permits the use of hollow-forged drums and welded drums where the method of welding has been specifically approved and the efficiency of the welding will be guaranteed by tests proposed by the manufacturer and considered completely adequate by the Bureau.—Editor.

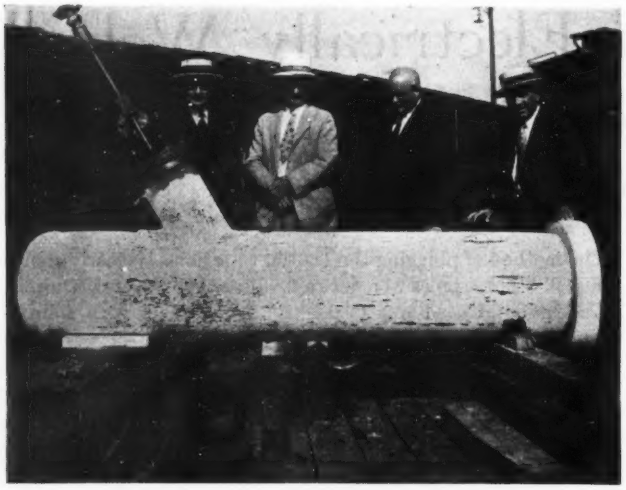

FIG. 3 SHOWING YIELDING OF $^1/_2$-IN. PLATE. PRESSURE, 1700 LB. PER SQ. IN.

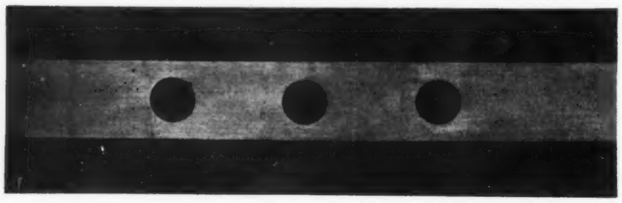

FIG. 6 TEST SPECIMEN OF THREE PIECES OF BOILER PLATE WELDED TOGETHER AND THEN MACHINED TO SIZE

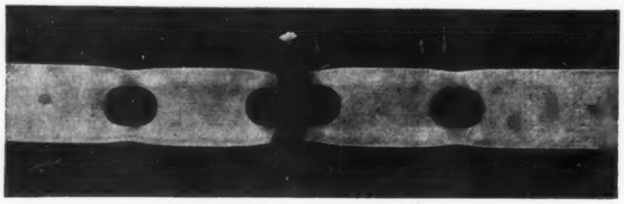

FIG. 7 RUPTURE OF TEST SPECIMEN SHOWN IN FIG. 6

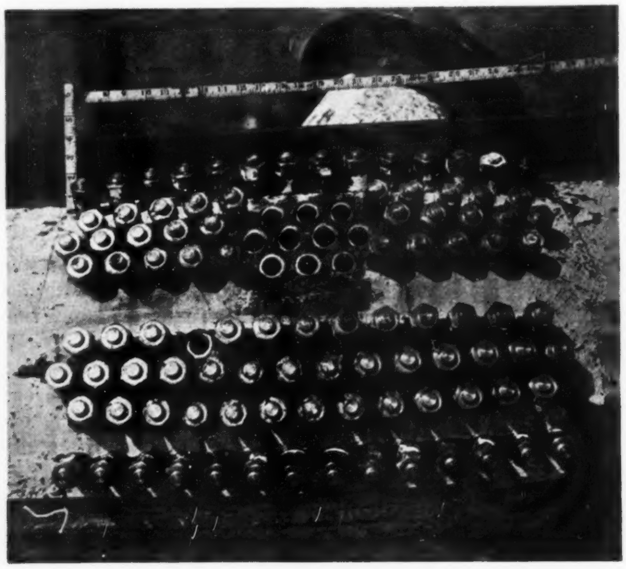

FIG. 4 SHOWING LIGAMENT THAT FAILED. ALSO GENERAL YIELDING OF $1^1/_4$-IN. TUBE SHEET

FIG. 5 CLOSE-UP VIEW OF LIGAMENT THAT FAILED

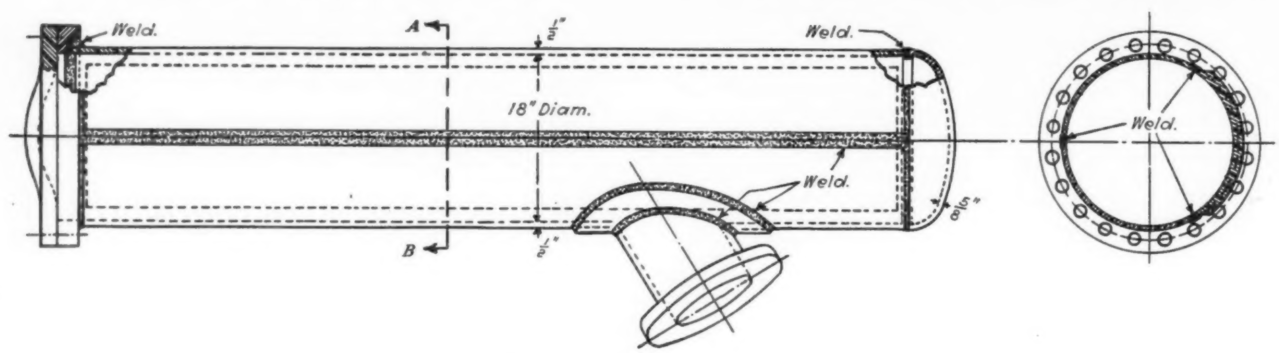

FIG. 8 GENERAL DIMENSIONS OF DRUM TESTED, SHOWING LOCATION OF WELDS

One of the methods of testing the effectiveness of the weld is illustrated in Figs. 6 and 7, where three pieces of boiler plate are shown welded together. After welding, these specimens were machined to a final width of 2.220 in. and a thickness of 1.111 in., and then lightly etched to distinguish the weld. Three $1^1/_4$-in. holes were drilled through the test specimens: one tangent to a weld, one in the parent metal, and one in the center of the weld. The specimens broke through the hole in the parent metal as shown in Fig. 7. The results obtained were as follows:

Total load at yield..........	46,550 lb.	43,200 lb. per sq. in.
Total load, ultimate.........	68,110 lb.	63,300 lb. per sq. in.
Elongation in 2 in., per cent...	25	
Reduction of area, per cent..	48.8	

Markings on Bullets and Shells Fired From Small Arms[1]

A Study of the Engravings Made on the Cylindrical Portions of Bullets by the Lands and Grooves of Bores of Firearms, and of Breech-Block Imprints on Cartridge Cases and Firing-Pin Imprints on Primer Cups

By CHARLES O. GUNTHER,[2] HOBOKEN, N. J.

IN AN ARTICLE published in the February, 1930, issue of MECHANICAL ENGINEERING, the author presented the subject-matter of bullet and shell markings in its simplest aspects as exemplified in the automatic pistol, caliber .45, model of 1911, U. S. Army. It was shown that the cylindrical portion of the bullet is engraved by the lands and grooves as it passes through the bore of the weapon, and that it is from an analysis of this engraving that the characteristics of the bore are determined in order to establish the identity of the weapon from which a given bullet was fired. The ejected cartridge case carries the breech-block and firing-pin imprints as well as the marks left by the extractor, and these offer evidence for the purpose of identifying the weapon from which the cartridge case was ejected. The underlying principle may be stated, somewhat crudely, perhaps, as follows:

If a surface is brought in contact under pressure with another harder surface, the resultant effect upon the softer surface will depend upon the relative hardness of the two surfaces, the character of the harder surface, the magnitude of the pressure, and the relative motion of one surface with respect to the other.

Surfaces which have been subjected to machining operations; the impression of the breech block on the base of the cartridge case and the primer cup; the engraving of the jacket of the bullet as it passes through the bore; the marks left by the extractor on the cartridge case; the crater formed in the primer cup by the firing pin; the marks made by the die in drawing the jacket of the bullet — all these are illustrative of the principle stated above.

The conditions existing in the bore of a new barrel are the result of the operations incident to its manufacture. In this connection it is of interest to note that the Ordnance Department manufactures a pair of barrels for this pistol from a single forging, as shown in Fig. 1. After certain machining operations and the rifling operation are completed, the barrels are separated. Fig. 2 shows the barrels as they appear before separation. Since the ends of the forging form the muzzle ends of the finished barrels, it follows that in cutting the grooves of the rifling, the tool has traveled in a direction from breech to muzzle in one of the barrels and in the reverse direction in the other barrel. The barrels are not lead lapped after the rifling operation.[3] Barrels are lead lapped to remove some of the tool marks as well as to remove the sharp edges of the lands which are left by the rifling tool. The usual practice is not to lap the barrels of pistols and revolvers which are designed primarily for use with the metal-jacketed bullet.

The forcing cone is formed by chamfering the breech ends of the lands. The lands rise to their full height of 0.003 in. in a distance of 0.086 in. from the beginning of the bullet seat. Fig. 3 is a view of a section of an old barrel showing the bullet seat and the forcing cone. The end of the land *ab* shown in Fig. 4 (reproduced from Fig. 6 of previous article in the February issue) is to be interpreted as that part of the surface of the forcing cone in contact with the surface of the bullet, and the edge of the land *ab* is to be regarded as the intersection of the cylindrical surface of the land with the conical surface of the forcing cone.

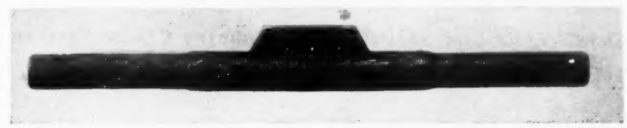

FIG. 1 SINGLE FORGING FOR PAIR OF BARRELS FOR ORDNANCE DEPARTMENT AUTOMATIC PISTOL

FIG. 2 BARRELS OF FIG. 1 AFTER MACHINING BUT BEFORE SEPARATION

In the manufacture of ammunition for this weapon,[4] present methods of the Ordnance Department provide for seating the bullet in the cartridge case without crimping the cartridge case to the bullet and without the use of indents. The jacket

[1] A partial statement of results of a research being aided by Engineering Foundation. See previous article in MECHANICAL ENGINEERING, February, 1930, pp. 107–113.

[2] Major, Ordnance Reserve, U. S. A. Consulting Engineer and Professor of Mathematics, Stevens Institute of Technology. Mem. A.S.M.E. Professor Gunther received his degree of M.E. from Stevens Institute in 1900, in which year he joined its faculty as an instructor. He was appointed to his present position in 1908. In 1918 and 1919 he was with the Ordnance Department of the United States Army, during which time he was closely associated with the experimental and development work in small arms and small-arms ammunition at Springfield Armory and at the Small-Arms Ballistic Station, Miami, Fla.

[3] An analysis of the engravings on the jackets of bullets fired from a pair of barrels so manufactured at Springfield Armory will form the subject-matter of a subsequent article.

[4] No detailed description of various types of weapons and ammunition is contemplated, as there are a number of excellent books published which cover this subject, e.g.:

"Pistol and Revolver Shooting," by Major Julian S. Hatcher.
"American Small Arms," by Edward S. Farrow.
"Fire Arms in American History," by Chas. W. Sawyer.
"Pistol and Revolver Shooting," by A. L. A. Himmelwright.

of the bullet is made of gilding metal, and the core is a composition of lead and antimony.

The cartridge, although rimless, is intended also for use, when clipped, in both the Colt and Smith & Wesson army revolvers, M-1917. The original purpose of the crimp was to prevent the bullet in the cartridge case from moving forward, as

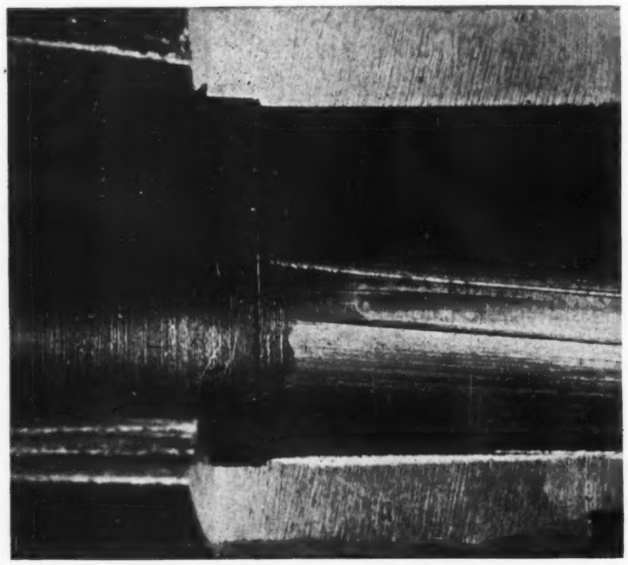

Fig. 3 Section of an Old Barrel Showing Bullet Seat and Forcing Cone

in firing a revolver it occasionally happened that, when one or more shots were fired, the bullets of the unfired cartridges moved or jumped forward so that their points jammed against the side of the barrel under the frame, thereby preventing the cylinder from revolving. The cannelure in the cartridge case, just below the base of the bullet, when seated, (Fig. 5) prevents any movement of the bullet backward. Such backward movement would be dangerous, as it would reduce the volume of the powder chamber and result in developing excessive pressure.

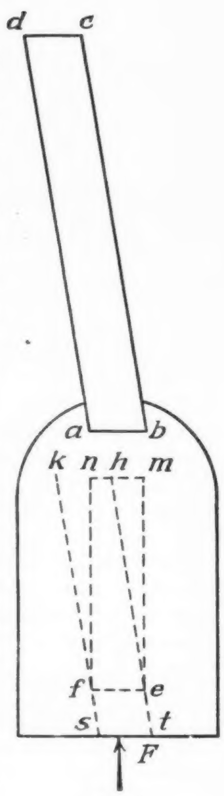

Fig. 4

The automatic pistol is also manufactured by the Colt's Patent Fire Arms Mfg. Co. and is known as their Government Model, Automatic Pistol, Caliber .45. The Colt barrels are each manufactured from special rolled steel which is made up to their own specifications. The rifling tool is drawn through one barrel at a time in the direction from breech to muzzle, and the barrels are not lead lapped after the rifling operation.

It is of interest to note that in the case of the automatic pistol one may find an ejected cartridge case with a primer presenting an appearance as shown in Fig. 6. The pressure developed in the barrel has forced the soft metal of this particular primer cup into the hole in the breech block around the firing pin, to such an extent that this metal is "wiped" over the crater in the process of ejection. The automatic pistol automatically ejects the exploded cartridge case and reloads from a magazine; it is, however, necessary to pull the trigger to fire each shot. In the process of ejection the base of the cartridge case moves downward, while the mouth of the cartridge case moves upward and to the right; it is in this downward movement of the base of the cartridge case that the tiny teeth in the lower half of the circumference of the hole through which the firing pin strikes (see Fig. 7) produce the marks shown on the primer cup in Fig. 6.

In the automatic pistol the pressure of the powder gases expands the cartridge case; this expansion tends to prevent the escape of gases to the rear. There is some escape of powder gases past the bullet as it moves through the bore; but the pressure of the gases exerted on the base of the bullet tends to give obturation, as a bullet under normal conditions eventually expands so as to practically fill up the grooves of the barrel.[5]

The analysis of the markings on bullets fired from a revolver presents a more complex problem than in the case of bullets fired from the automatic pistol. Some of the reasons for this will be found in the following.

In the automatic pistol the chamber is an integral part of the

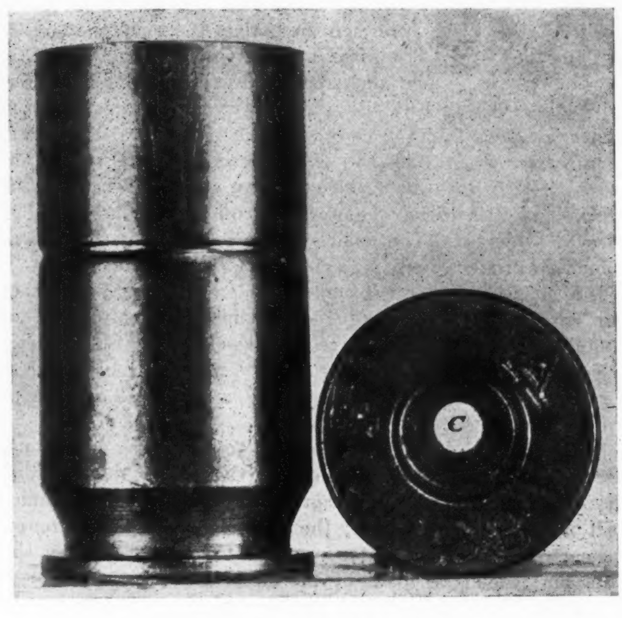

Fig. 5 Cartridge Case

barrel. When a cartridge is chambered, the mouth of the cartridge case seats against a square shoulder and the bullet lies in the bore in close proximity to the forcing cone. In the revolver the chambers are located in the cylinder, and when a chamber is in line with the barrel it is separated from the barrel by an air space. When a cartridge is chambered, the rim at the base of the cartridge case seats against the cylinder and the bullet lies in the chamber at some distance from the forcing cone in the barrel. In some revolvers the cylinder is chambered for a particular type of cartridge; in others the cylinder chamber is of uniform bore. In general the ammunition manufactured for use in revolvers has the mouth of the cartridge case crimped to the bullet.

[5] See "Spark Photography and Its Applications to Some Problems in Ballistics," by Philip P. Quayle, in Scientific Papers of the Bureau of Standards, no. 508. Also "Recoil in Revolvers and Pistols—Its Causes and Effects," by the same author, in *The American Rifleman*, June, 1930, p. 17.

In the automatic pistol the bullet is well in contact with the lands before the base of the bullet is out of the cartridge case; in the revolver the bullet does not as a rule come in contact with the lands until after the bullet is entirely free from the cartridge case; it has attained considerable velocity when it strikes the forcing cone, with the result that, due to inertia, in the case of a jacketed bullet the core is driven into the jacket, increasing its diameter, and in the case of a lead bullet, its length is shortened, with a consequent increase in diameter. The use of improper ammunition in a revolver may produce conditions which would result in splitting the barrel. In the revolver the bullet must jump from the cylinder chamber into the barrel, with an attendant escape of powder gases between the cylinder and the breech end of the barrel. This escape of gases also explains why a revolver cannot be silenced. The pressure of the powder gases expands the cartridge case, and this expansion tends to prevent the escape of gases to the rear; but there is also some escape of powder gases past the bullet as it moves through the bore of the barrel.

FIG. 6 EJECTED CARTRIDGE CASE SHOWING SOFT METAL OF PRIMER CUP WIPED OVER CRATER IN PROCESS OF EJECTION

FIG. 7 VIEW OF BREECH BLOCK OF PISTOL WITH FIRING PIN AND EXTRACTOR REMOVED

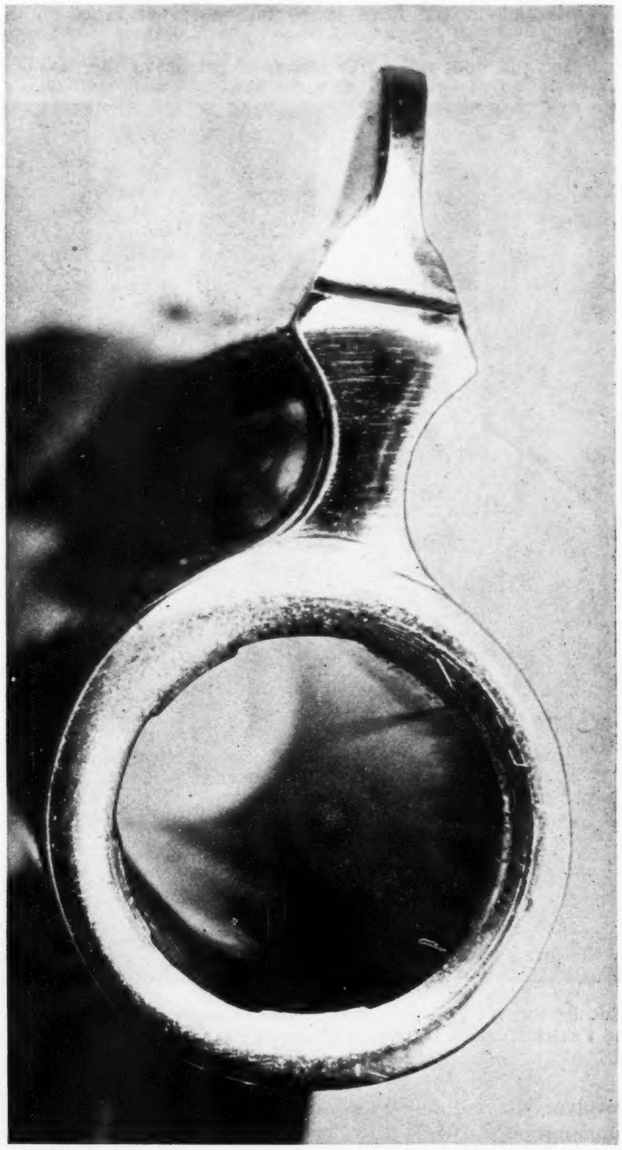

FIG. 8 VIEW LOOKING INTO MUZZLE OF BARREL OF A SMITH & WESSON SAFETY HAMMERLESS REVOLVER, CALIBER .38

In a revolver, under ideal conditions, the chamber and barrel are in perfect line—the axis of the bore is coincident with the axis of the chamber in the cylinder—and the bullet moves through the chamber and bore with its axis coincident with the axis of the bore. The following conditions, when present, are disturbing influences:

Cylinder chamber is out of line with the barrel and therefore the bullet does not strike the forcing cone true; it will also cause a certain amount of the bullet to be sheared off by the barrel.

Play in the axis of the cylinder.

Variations in the head space and barrel clearance on the cylinder.

Firing pin does not strike center of primer in the case of a revolver adapted to center-fire ammunition.

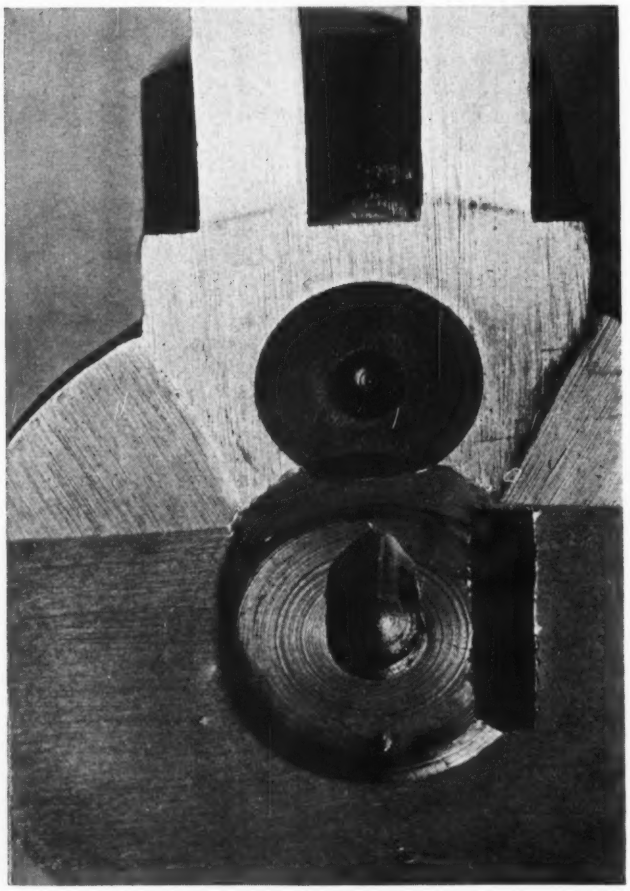

Fig. 9 Smith & Wesson Safety Hammerless Revolver—View of Frame Back of Cylinder Showing Recoil Plate and Firing Pin

Fig. 8 is a view looking into the muzzle of the barrel of a Smith & Wesson revolver, caliber .38, Safety Hammerless, New Departure, loaned by Major D. B. Wesson. The barrel is 3.25 in. long and is lead lapped. The rifling consists of five helical grooves cut in the surface of the bore and is of uniform right-handed twist, making one complete turn in 18.75 in. The grooves are 0.114 in. wide and 0.005 in. deep. The lands are 0.1059 in. wide. The bore diameter has a small limit of 0.350 in. and a large limit of 0.351 in. The cylinder is 1.215 in. long and has five chambers. The chamber diameter has a small limit of 0.388 in. and a large limit of 0.389 in. The diameter of the charge hole at the front end of the chamber is 0.362 in. The bullet is seated in the cartridge case to a depth of 0.25 in. and moves forward about 0.6 in. before it comes in contact with the forcing cone in the barrel.

Fig. 9 is a view of the frame back of the cylinder showing the recoil plate and the firing pin. Fig. 10 shows the firing-pin imprint in the primer of a cartridge that was fired in this revolver.

Fig. 11 shows corresponding surfaces of three bullets fired from the same chamber in this revolver. These bullets are all from ammunition manufactured by the Western Cartridge Co. The one on the left is a 145-grain Lubaloy-coated bullet; the one in the center is a 145-grain lead bullet; and the one on the right is a full-metal-patch (jacketed) bullet from a cartridge loaded with smokeless powder. Each bullet was fired from a clean barrel. In each bullet, the groove shown in the illustration

Fig. 10 Showing Firing-Pin Imprint in Primer of Cartridge Fired in Smith & Wesson Safety Hammerless Revolver

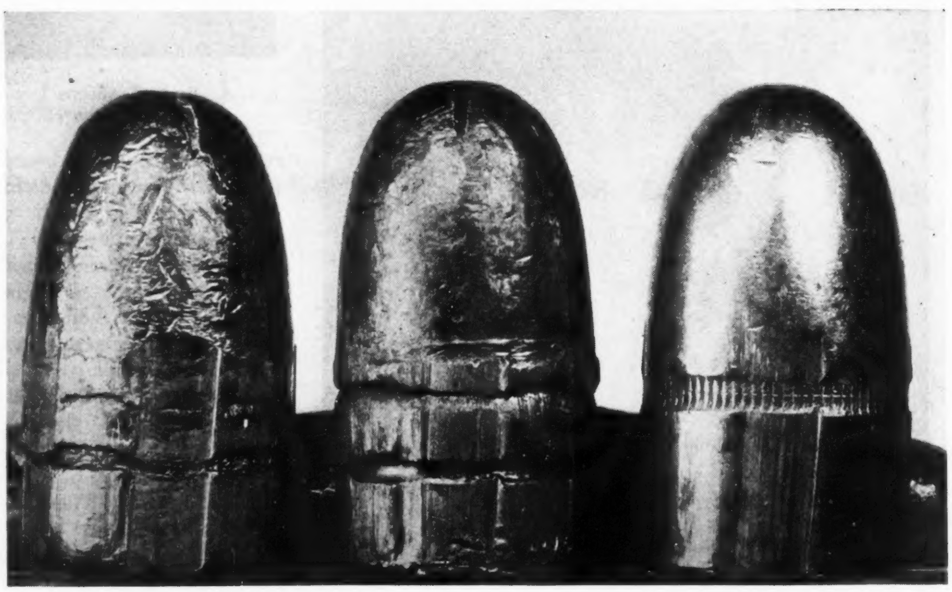

Fig. 11 Corresponding Surfaces of Three Bullets Fired From the Same Chamber of S. & W. Revolver

was made by the same land of the bore; the groove width is narrowest in the jacketed bullet on the right, and widest in the lead bullet in the center. This indicates that there was less stripping in the case of the jacketed bullet than in the cases of the other two types of bullets.

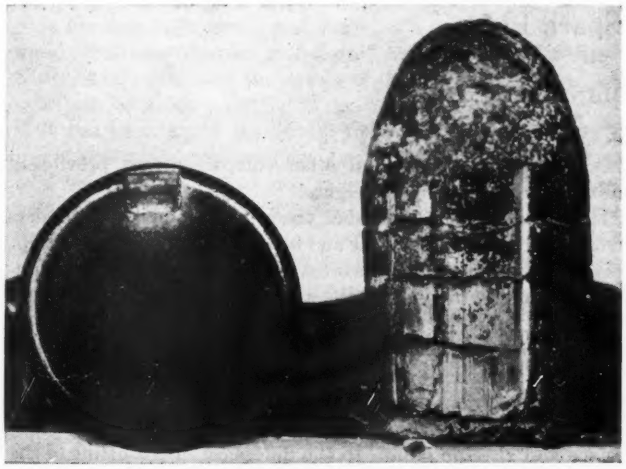

FIG. 12 IMPRESSION OF NOSE OF HAMMER ON BASE OF A RIM-FIRE CARTRIDGE CASE FIRED IN AN OLD S. &. W. CALIBER .32 REVOLVER

Fig. 12 shows the impression of the nose of the hammer on the base of a rim-fire cartridge case fired in an old S. & W. revolver (No. 5050) of caliber .32, and also the lead bullet from this cartridge.

Fig. 13 shows two caliber .38 lead bullets fired from a low-priced revolver, and illustrates what happens when a bullet

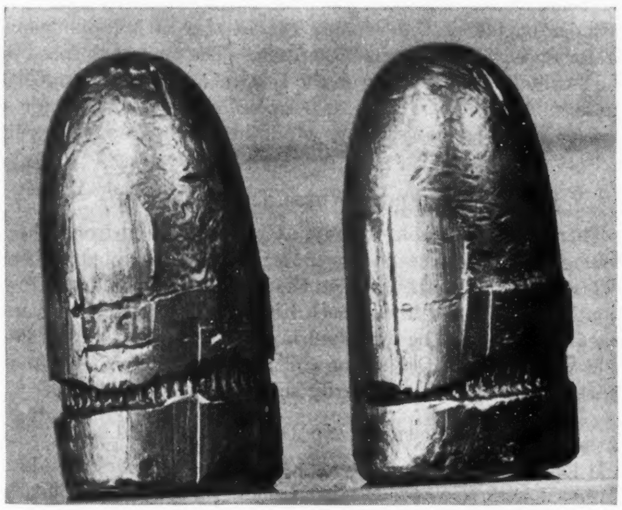

FIG. 13 TWO CALIBER .38 LEAD BULLETS FIRED FROM A LOW-PRICED REVOLVER

(Showing what happens when a bullet strikes the forcing cone with its axis inclined to the axis of the bore on account of the firing pin striking the primer off center.)

strikes the forcing cone with its axis inclined to the axis of the bore on account of the firing pin striking the primer off center.

Fig. 14 is a composite photograph; the upper part is a portion of a lead bullet fired from a revolver, and the lower part is a portion of a lead slug which was forced through the same barrel. The reason for the perfect matching of certain lines lies in the fact that the bore of this particular revolver had some very pronounced tool marks in one of the grooves. These tool marks ran the full length of the bore and produced the lines on both the bullet and the slug that are seen to match in the photograph.

Conditions existing in the bore right at the muzzle may play a very important part in engraving the surface of the bullet, and this is especially true in the case of a lead bullet.

In conclusion the author wishes to extend his thanks and appreciation to the following for their cooperation:

Hon. Arthur S. Tompkins, Justice, Supreme Court, State of New York

Hon. Morton Lexow, former District Attorney, Rockland Co., N. Y.

Ordnance Department, U. S. A.

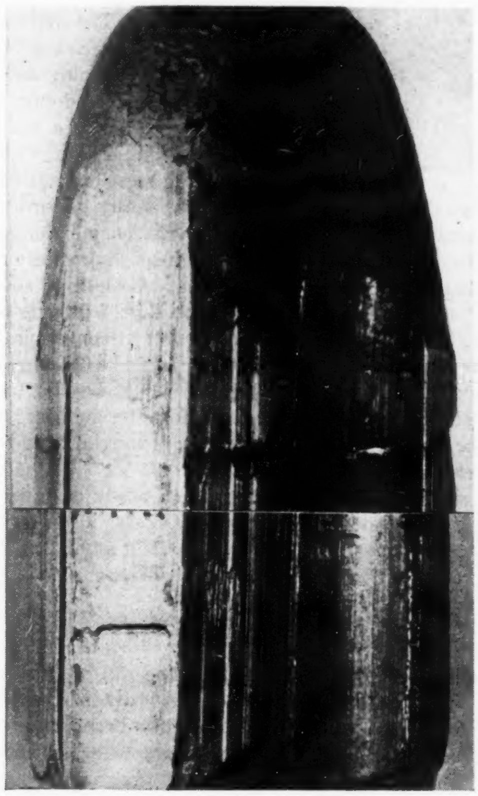

FIG. 14 COMPOSITE PHOTOGRAPH: UPPER PART IS A PORTION OF A LEAD BULLET FIRED FROM A REVOLVER; LOWER PART IS A PORTION OF A LEAD SLUG FORCED THROUGH THE SAME BARREL

Major D. B. Wesson
Colt's Patent Fire Arms Mfg. Co.
Remington Arms Co., Inc.
Webley & Scott, Ltd.
Mauser-Werke Aktiengesellschaft
Western Cartridge Co.
Winchester Repeating Arms Co.
United States Cartridge Co.
Peters Cartridge Co.
Iver Johnson's Arms & Cycle Works
Harrington & Richardson Arms Co.
Harry F. Butts, Commanding Officer, Ballistic Bureau, New York Police Dept.
Auguste G. Pratt, President, The Babcock & Wilcox Co.
F. T. Llewellyn, U. S. Steel Corp.

Engineering Problems of Modern Motor Cars

Number of Cylinders, Bore and Stroke Ratios, Speed, Front Drive, Three- and Four-Speed Transmissions, Details of Engine Parts, Shapes of Combustion Chambers, and Location of Spark Plugs

By WM. G. WALL,[1] INDIANAPOLIS, IND.

EXACTING requirements of the motoring public and great competition in marketing are keeping the motor-car engineer busier than ever in spite of the apparent standardization of automobile design. The engineer must first advise the management on the general type of car to build; second, he must determine how the adopted specifications can be worked into a model that can be sold in competition with other makes; and third, most difficult of all, he must design details so they will give satisfactory performance.

Such questions arise as to whether the engine should be of six-, eight-, or even sixteen-cylinder, high-speed or medium-speed type; whether the new fetish of front-wheel drive should be adopted; and whether the transmission should provide three or four speed changes. Other questions are: Should spiral-bevel, hypoid, or worm drive be used; what should be the length of the wheelbase; and what type of brakes should be adopted? All these questions have to be answered before the engineer begins to lay out the car, although at times policy of the company provides the answer to some of them in advance.

Although the modern car has as much power as is necessary, the public is still demanding more. Greater acceleration, the ability to climb any grade on high gear and at high speed, and quiet operation of the engine and the entire car are demanded by the public.

Multiple-Cylinder Cars Here to Stay

The multiple-cylinder engine is here and will probably always remain. In fact, the number of cylinders is gradually increasing. Some years ago two well-known companies brought out 12-cylinder engines which were given up as not being entirely satisfactory. For a while it looked as though the greatest number of cylinders to be used for all time would be eight. Recently, however, the advent of the 16-cylinder Cadillac has stirred up considerable enthusiasm among engineers so that now several 16-cylinder engines are being designed and are nearly ready for the market, while two companies are bringing out cars with 12-cylinder engines and several other companies that previously built sixes are bringing out eights.

There is no question but that the greater number of cylinders gives a much smoother torque and has very few drawbacks except that of additional cost. It is often said that the greater the number of cylinders, the greater the amount of trouble, but this has been found not to be true. An 8-cylinder engine today gives no more trouble, if as much, as did the 4-cylinder engine of yesterday. Engineers are concerned, however, over the slightly increased piston friction which results as the number of cylinders increases. This is due to the greater percentage of piston rubbing surface and also, no doubt, to the difference in the fitting of the large number of pistons.

Engine Speed Increasing

The speed of the engine must also be taken into account, for, although some companies advocate what they call medium-speed engines, the speed of all engines is gradually going up, increased speed being one of the simplest ways of getting more power with the same displacement.

The increase in the speed of passenger-car engines, while not having kept up with that of racing-car engines, has not lagged far behind. Records show that the maximum speed of the 4-cylinder engine of the winning car in the 1912 Indianapolis Motor Speedway Race was 2200 r.p.m. The maximum speed of the 8-cylinder engine that won the 1929 race was more than 6000 r.p.m. Twenty years ago, 2000 r.p.m. was a fair speed for a passenger-car engine. Today, a number of these engines run at least 4500 r.p.m.

Front-Wheel Drive

There is considerable interest at present in the front-wheel drive due to the advent last year of the Cord, and probably there will be more cars of this type on the market within the next few months. While the front-wheel drive has a number of advantages that will not be discussed in this paper, the only disadvantages known to the author are the somewhat greater cost of construction and the necessarily slightly longer wheelbase.

Transmissions and Other Elements

It looked very much last year as though many cars would be equipped with four-speed transmissions. Today the tendency is not quite so strong, as the four-speed transmission has not accomplished what was expected of it. The low speed is very seldom used, and what results, and what is advocated for the future, is a three-speed transmission with a quiet second, like the supposedly quiet third of the four-speed transmission, and an internal gear clutch in connection with the second speed. In other words, the transmission of the near future will be the present four-speed transmission without the low speed.

For several years there has been a competition between hydraulic and mechanical brakes. The hydraulic brake seems to be gradually gaining ground.

The question of whether to use the spiral-bevel, hypoid, or

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worm gear is very much one of cost, the hypoid generally being preferred over the spiral-bevel where cost is not a big factor. The worm drive, although having some advantages, has made very little headway in passenger cars and is much more expensive.

Cost

In keeping down the cost of design of a motor car, there are a number of general rules to follow. As the problem of cost is closely connected with the details of design, only a few of these rules can be given.

It has been found that costs are materially reduced by the use of steel stampings in place of castings for such parts as rear-axle housings, front and rear engine arms, all frame members, parts of transmission cases, brake drums, engine oil pans, valve covers, and other pieces of this nature. Stamped body panels are also playing a big part in reduction of cost. Another factor in lowering costs is the use of interchangeable parts as, for example, using the same cylinders for a six as for an eight so that the same pistons and rods can be used, interchangeable bearings for different models, and demountable wheels which make the front and rear wheels interchangeable with the exception of the hubs.

Details of Design

The details of the design and the care with which they are worked out are, if anything, more important than the general specifications. For instance, if it is desired to design an engine for a certain displacement and maximum power, the bore would be made nearly equal to the stroke, resulting in what is called a square engine, but as it is generally desirable to limit the length of the engine so as not to have too long a wheelbase, this tendency cannot always prevail, and at present the stroke is generally made one-fourth to one-third longer than the bore although some of the later engines are nearly square.

Light reciprocating parts, such as aluminum pistons, are now generally used except by a few companies that will stick to cast-iron pistons. Duralumin rods, while used to some extent, have not proved to be popular.

Next to increasing the displacement of an engine, the simplest way to get greater power is to increase the speed of the engine.

Pistons

Without question the biggest problem in the construction of reciprocating engines today concerns pistons. Most any piston will work, but very few work right, the main troubles being that they score, slap, will not hold compression, allow oil to go by, or are too heavy and do not carry off the heat.

Cast-iron pistons were first used and are still being used to a great extent. As the cast-iron piston has the same coefficient of expansion as the cylinder, there is not such a great difference in the amount of expansion between the two parts, although the piston, getting much hotter than the water-cooled, or even the air-cooled, cylinder walls, does expand somewhat more.

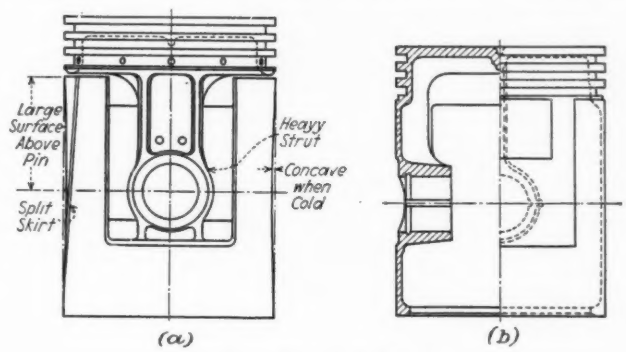
The weight of the cast-iron piston is an objection, especially in high-speed engines. The fact that it does not carry off the heat, the conductivity not being very high, and therefore has a hotter head than the aluminum piston, is also somewhat detrimental.

The great problem in regard to pistons, aside from making them run quietly—that is, not slapping—and keeping the weight down, has been to keep the oil from getting into the combustion chamber, fouling the plugs and the valves, and thus being wasted. All types of rings and grooves for rings have been used to prevent this.

The aluminum piston has made great headway and has a number of advantages. It did not make much headway, however, until, several years after its first introduction, the skirt was separated from the head. Today most aluminum pistons are of the skeleton type. The advantage of the split-skirt type is that the piston can be fitted fairly tightly when the cylinder is cold, so that it will not slap, and yet it will not score when it gets hot and expands. Much difficulty has been experienced with this type of piston because of the large consumption of oil, and much experimental work has been done to eliminate this trouble. Considerable research on rings has demonstrated that they play only a small part in the prevention of oil leakage and that the design of the piston has as much if not more to do with eliminating this than do the rings.

Recently manufacturers have been experimenting with cylinders having a high rate of expansion in which trunk-type pistons, not split, can be used which will not slap when cold or score when hot. This cylinder material is an alloy, generally a chrome-nickel cast iron, and seems to have a number of advantages. With trunk-type pistons it is fairly easy to control the oil leakage.

Interesting results have come from experimental work on oil leakage by the piston, especially with the skeleton type of aluminum piston. It has been found that if a piston moves perfectly in line with its direction of travel there is very little pumping of the oil by the oil rings in the grooves, but if the piston "teeters," then there is an excessive amount of pumping and much oil is consumed. There are a number of ways of preventing this. One is to hollow-grind the skirt of a skeleton piston so that, when it becomes heated and expands, the center will bulge no more than the ends. The idea is to make the skirt perfectly parallel at high temperature, which means that it must be concave at low temperature. Making the skirt much longer above the piston pin helps materially. The length of bearing of the skirt between the piston-pin boss and the head is of great importance. The skirt should be quite rigid and so designed that the heat flow from the piston-pin boss to it will be uniform. In nearly all aluminum pistons the skirt is separated from the piston head by a saw cut around all or part of the periphery of the piston.



PISTONS FOR MOTOR-CAR ENGINES

(a) Showing requirements of a good aluminum piston: namely, thick head to carry off heat; split skirt to take up expansion; annular slot separating skirt from head; heavy strut to hold skirt rigid; and large surface above pin.
(b) Conventional cast-iron trunk type. Very little trouble with oil getting past a piston of this kind.

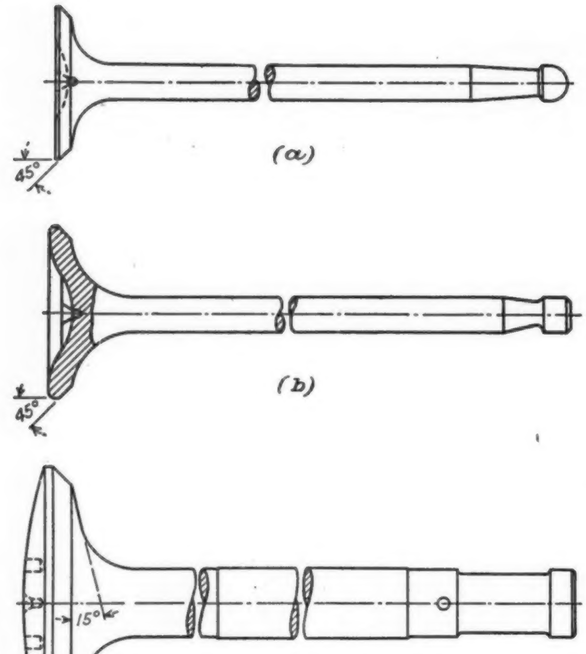
Piston Pins

The method of fastening piston pins has changed within the last few years. The piston pin was originally held in the piston with setscrews, the bearing being in the upper end of the connecting rod. Now this is seldom done as there is a tendency to scoring by the piston when the pin gets hot and expands. The almost universal practice at present is either to use a pin clamped by the rod and free in the piston or else a floating pin which is free to move in both piston and rod bearing.

Cast-iron pistons with floating pins and no bushings have been

tried many times, but experience has taught that bronze bushings are quite necessary in cast-iron pistons. Aluminum pistons, however, are quite satisfactory without being bushed for the pins.

In order to conduct the heat away from the head of the piston, a slight taper from the top toward the skirt is found in the best designs. Today, most pistons have considerably thicker heads than formerly. The newer pistons for airplane engines have heads more than 1 in. thick for sizes of $4^1/_2$ in. bore and larger. The object is to conduct the heat away more rapidly.



Types of Valves

(*a*) Conventional small bus valve with spherical end, which always allows tappet to contact with center of valve stem. Made of chrome-nickel steel. Flat-topped head not considered good practice.
(*b*) Valve with semi-tulip type of head and 45-deg. valve seat. Made of chrome-nickel steel. Streamlined under head and very efficient.
(*c*) Conventional type of Diesel valve. Note that valve head has a convex top and that stem is undercut near head.
(*d*) Flat-seated valve. With the same size and lift it has a greater port opening.
(*e*) Hollow-stemmed airplane-engine valve. Tungsten-lipped. Hollow filled with salt.
(*f*) Salt-cooled motor-bus valve. Very good shape of valve. Has hardened tungsten plate at bottom of stem. Filled with KNO_3.

A piston pin must possess three qualities; it must be hard, perfectly round, and extremely smooth. Generally a scleroscopic hardness of 80 deg. is specified. A pin to act properly must be nearly perfectly round, certainly not out of round more than 0.00025 in. The other requisite, that of smoothness, means that the surface must look smooth even under the microscope in order to give the best service. This is accomplished by careful grinding and lapping.

Rings

It is common practice to use two compression rings and one oil ring, or three compression rings and one oil ring. Sometimes two oil rings are used. Generally oil rings are placed above the piston pin, although in some of the V-type engines an oil ring is placed below the piston pin when cast-iron or trunk-type pistons are used. Innumerable ring designs have been placed on the market. All of them have some merit, although some are very complicated, consisting of several pieces. The present practice is to use plain rings, either cast or hammered, for, if the pistons are properly made, almost any ring will hold the compression and keep down the oil.

Valves

While many different types of sleeve valves have been tried out, and, in fact, are still being tried out, none of them, with the exception of the Knight double-sleeve valve, has made any material progress and nearly all engines today use poppet valves.

A great diversity of material is used in poppet valves, most of the original ones having been made with cast-iron heads.

The admission valve does not give much trouble if properly ground and seated, but the exhaust valve in all gasoline engines is a continual source of trouble. It has, in fact, given very much more trouble than most designers realize. A good exhaust valve should not warp, rust, or scale; it should not, at high temperatures, pull out of shape, should be a good heat conductor, and, of course, should not break. The metals generally used and which have been found to be the best for valves are nickel, chromium, and tungsten alloy steels. High nickel and chromium seem to give the best results. It has been found on recent tests that the carbon in the steel should not be more than 0.50 or 0.60. Nickel up to 28 per cent and chromium up to 12 per cent have been found to be very beneficial, giving even better results than tungsten.

A most remarkable discovery is that a considerable amount of additional power may be obtained from a poppet-valve engine by preventing the warping of the exhaust valve and seat, even though this warpage may be very little, by seeing that the valve has a large amount of water around it, or has better radiating fins in case it is air cooled. The valve-stem guides should come up as near the head as possible on exhaust valves. On all water-cooled engines a certain amount of water has always been circulated around the exhaust-valve seat, but the amount has generally been skimped. Within the last few years most engine builders have provided more water around the seat, and it has been interesting to note the difference in the sustained horsepower of a particular engine when this has been done. This additional water not only prevents the warping of the valve but, by keeping the valve properly cooled, has eliminated the tendency to preignition which some engines have, and has also prevented the formation of carbon on the valves and seats.

The size of the poppet valve depends greatly upon the results desired. For maximum power at high speeds the valves should

be quite large in proportion to the displacement. It must be realized, however, that a large valve can cause more trouble than a small one on account of the difficulty of cooling it and also on account of its weight.

Valves must seat properly. Better seating, as far as holding compression is concerned, is obtained if the seat is quite narrow, $^3/_{64}$ in. wide for a small valve, say, $1^1/_2$ in. in diameter. There are only two ways in which heat is carried away from a valve: one is through the seat and the other through the stem, and therefore it is necessary for the seat to be at least $^1/_{16}$ in. wide; and for a valve of the size stated, most manufacturers use a $^3/_{32}$-in. seat. This seat gets wider as the engine grows older and the valves are ground in.

It is common practice to make the exhaust valve about 10 per cent smaller than the admission valve. It is difficult to show from tests that there is any disadvantage in doing this, and as the shapes of the intake and exhaust valve under the head are generally different because of their different functions, they cannot be interchangeable even if they are of the same size.

The use of multiple valves has become quite popular, especially with the valve-in-the-head type of engine in which there are four valves—two intake and two exhaust valves to a cylinder. This arrangement has not only the advantage of the large amount of area for the admission and exhaust, but also allows the spark plug to be put in the most advantageous position at the center of the combustion chamber. The increase of power in some recent engines having four valves per cylinder and with the spark plug in the center of the combustion chamber, as against two valves with even two spark plugs on the sides, is as much as 25 per cent in the same engine. This is about the same increase in power that would result from the use of a supercharger. A large part of this increased power is, however, due to the placing of the spark plug in the center of the combustion chamber.

MANIFOLDS

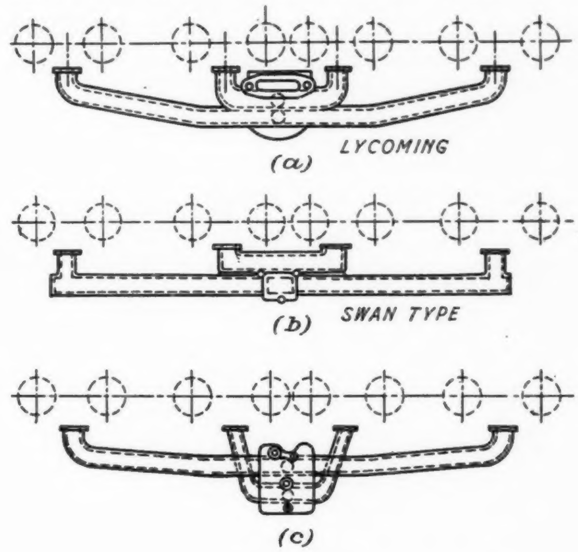
To go into the subject of manifolds thoroughly would require many volumes, and therefore it will be touched upon only slightly. Opinions differ as to how manifolds should be made. There is quite close agreement, however, in regard to what designers are striving for in manifolds for multiple-cylinder engines. The purpose is to obtain a uniform and equal distribution of the gas to all of the cylinders. Even more than this is necessary, however. The speed of the gas through the manifold should be constant, or there should be a gradual increase in speed from carburetor to valve port. It is very important that there be no large sections producing stagnant pools, so to speak, or any small section where there is wire-drawing. One reason that it is so difficult to make a proper manifold is the fact that for maximum power and speed a large section through the manifold is desirable so that a great quantity of gas can get through to the cylinders, whereas for slow running with the throttle partly closed, a small section is desirable in order to maintain the speed of gas stream. As it is difficult to secure such a change in the size of the manifold when the engine is running, a compromise is necessary. This results in reducing the size of the section to something between the two extremes.

As twin ports are used on many gasoline engines, it is necessary for the branches of any manifold to project into the engine at right angles so that the stream of gas will not be deflected against one side, producing too rich a mixture in the opposite cylinder. At the same time it has been found by repeated tests that the perfect right-angle manifold, with sharp corners instead of rounded ones, has undue friction and tends to hold back the charge for any particular size of section, making it impossible to get the maximum power out of the engine. Generally a compromise is effected by using branches long enough to straighten out the charge, even though quite large radii are used at the corners to reduce the gas friction.

The question of whether the manifold should be square or round in cross-section is of no great importance, although the best results seem to come from the use of the round manifold.

The opinion was held at one time that it was most important for each branch of the manifold to be of the same length. It has been found that the importance of this feature has been overestimated. The object is to distribute the fuel equally into the different ports, and a number of other factors of greater importance exist, such as the area of the cross-section of the riser and the different branches, the slope of the branches, and the proper amount of heat to apply and how it is regulated. The manifold should slope either toward the valves or back to the carburetor, so as to obtain proper drainage.

Temperature makes a big difference in the working of a manifold. In cold weather all the heat made will be needed, whereas in hot weather it is difficult to keep the manifold sufficiently cooled, with the result that the power generally drops off. The gas should have sufficient heat to vaporize it, and no more. The larger the section of the manifold in proportion to the gas flow, the more the heat necessary. The manifold should be designed so that there will be as little pulsation as possible, especially in an 8-cylinder engine firing in the usual way, 1–6–2–5–8–3–7–4.



MANIFOLDS

(a) Eight-cylinder manifold of streamline design. Rounded turns. For duplex carburetor.
(b) Eight-cylinder manifold. Sharp right-angled turns. One branch for Nos. 1, 2, 7, and 8 cylinders; other for Nos. 3, 4, 5, and 6 cylinders.
(c) Eight-cylinder manifold. Eliminates all back-and-forth pulsation.

It is difficult to say just what the limit of velocity of the gas in the manifold should be, as some of the best-working manifolds have sections which produce what seems to be an excessively high gas velocity. Up to 185 ft. per sec. is considered safe. Too small a section produces wire drawing and cuts down the power.

COMBUSTION CHAMBERS

The shape of the combustion space, the compression ratio, the location of the spark plug, and the position of the valves have been among the hardest problems to solve, due to the fact that so little is known about what is taking place in the combustion chamber when the engine is firing, and it has only been in the last few years that an inkling of just what does happen has been discovered. Quite a difference of opinion exists as to certain details of this question. There is no doubt, however, that

the compact combustion chamber has a number of advantages and will give higher efficiency, other conditions being equal. For this reason the T-head engine has practically gone out of existence, and the valve-in-the-head engine, in spite of being more expensive to build, has become more popular. The valve-in-the-head engine has a much more compact combustion space than the L-head engine, although, unless the combustion chamber of the former type is properly designed, it will be found to be very little, if any, more efficient than the L-head type of combustion chamber.

Compression ratios of gasoline engines vary from 4 to 1 to 8 to 1. Generally speaking, the higher the compression ratio, the more efficient an engine will be and the greater will be the power from a given cylinder, providing, however, that there is no knocking or preignition. These are two of the limiting factors in deciding compression ratio.

Special fuels, such as those using lead tetraethyl and other similar compounds, influence detonation decidedly and materially decrease the knock in an engine.

Preignition is generally caused by overheating of some part in or around the head; and quite often this is due to too high a compression ratio, to some projection in the cylinder, to the improper cooling of spark plugs, to the improper cooling or seating of this exhaust valve, or to a piston head that is too thin and does not carry off the heat. These are only a few of the causes.

The path of travel of the gas entering the cylinder, turbulence, and how much turbulence there should be are problems intimately associated with the shape of the combustion chamber. That at least a part of the cool gas coming in through the intake valve should pass over the exhaust valve is a practicable and generally accepted feature of design.

Opinions as to the exact shape of the combustion chamber vary. The Ricardo principle demands considerable turbulence, to produce which the shape of the combustion space should be such as to cover up part of the piston and also to leave a comparatively small neck between the combustion chamber and the cylinder through which the gas expands. In a modified form it has some advantages.

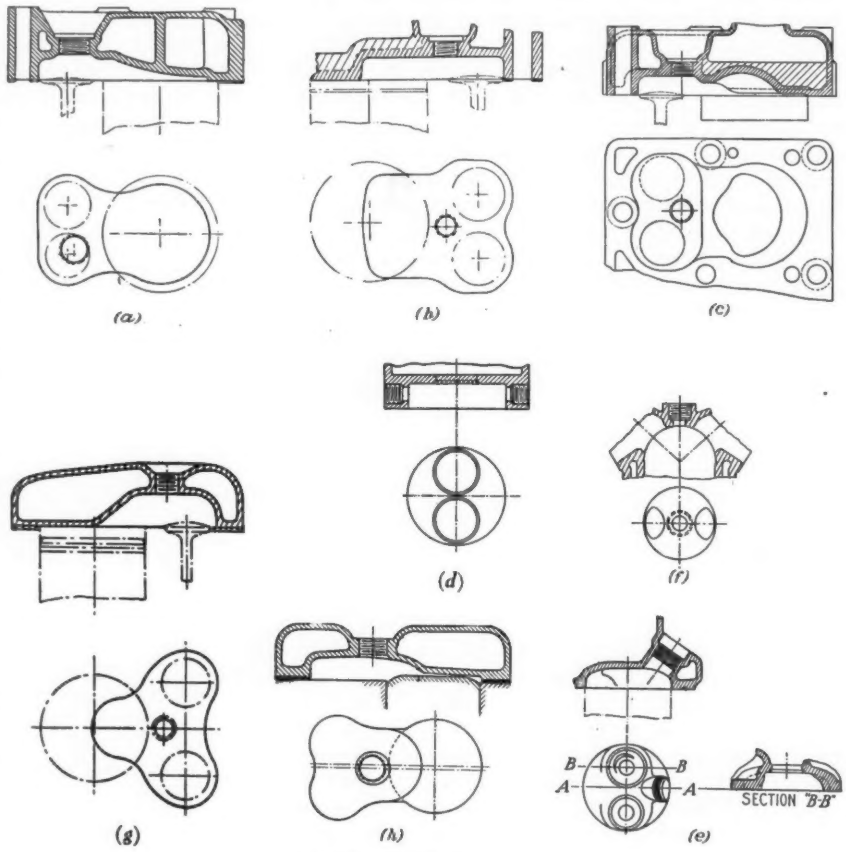
Another type of head, of which R. N. Janeway is the principal advocate, has an L-head combustion chamber with a vertical wall running straight across it at about the center of the piston. A double-dome head, developed by George H. Freers, has given excellent results.

The best results that the author has obtained in using the L-head combustion chamber have come from a combination of some of these ideas. This has resulted in a vertical circular wall near the piston center covering at least one-half of the piston, so that the distance between the piston and the head is not more than $^1/_{16}$ in. on small engines, and a broad neck or connecting chamber is used. This permits a higher compression ratio to be used, with less detonation and knock—possibly because of the cushioning effect of the explosion.

All of these shapes, however, depend greatly upon the position of the spark plug. Even with the best combustion chamber ever designed the improper location of the spark plug will give poor results. The best location of the spark plug for power, in the L-head type of combustion chamber, seems to be the center of a triangle formed by lines running through the centers of the valves and the near edge of the cylinder.

One of the most inefficient types of valve-in-the-head engine has a circular combustion chamber with the spark plug on one side, or with two spark plugs, one on each side. The most efficient type has four valves and a slightly domed or hemispherical head, provided the spark plug is placed in the center of the space between the four valves. Another type of combustion chamber nearly as efficient is the round head with two valves and a spark plug located at an angle between the valves and as near the center of the combustion space as possible.

In experimenting with different shapes of combustion space, designs are made as though maximum power depended on the shape of the chamber, while n reality the object is to get the power by using the highest compression possible, and to design a combustion chamber in which this high compression will not cause preignition, detonation, or knocking.



Combustion Chambers

(a) Conventional L-head design; not particularly efficient.
(b) Modification of Janeway and Whatmough type. Has spark plug near center of combustion chamber. Gives good results.
(c) Freers double-dome L-head. Spark plug near center of combustion space. Gives very good results.
(d) Conventional valve-in-head, two-valve circular combustion chamber with two plugs. Very little turbulence. Not efficient.
(e) Valve-in-head type; two valves. Spark plug near center of combustion chamber. Very efficient. Used on Marmon 16-cylinder engine.
(f) Romig type, valve in head. Two-valve combustion chamber. Efficient.
(g) Ricardo-type combustion chamber. Not efficient unless very much modified.
(h) Combustion-chamber L-head used in 1914 on National 12-cylinder engine. Somewhat similar to Ricardo type.

Combustion Radiation and the Planck Quantum Theory[1]

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IN THIS place it may be advantageous to restate the point of view from which this paper was prepared, and then to follow this with a statement of the conclusions which may now be drawn.

The question which prompted the investigation was this: What fractional part of the total energy released in a combustion process could possibly be radiated in quanta of such magnitude that the effect of such radiation is felt outside of the infra-red zone of the spectrum? Whatever this fraction is, it must, in evaluating the energy balance of the furnace, and hence in evaluating the distribution of the radiated energy, be given special consideration. As an extreme example, if some appreciable part of the energy released in combustion should be radiated in the frequency range of the X-ray, then this part of the energy will in radiation penetrate the gases in the furnace without affecting their temperature. The heat-balance equation of the furnace would then have to be set up to take this into account.

If this particular question should be put to a physicist it probably would be dismissed with the statement that X-ray radiations involving an appreciable part of the total energy of the process are impossible to any atmosphere in which the average intensity of the energy is no greater than that resulting in the usual combustion reaction. The physicist's sense of proportion in the realm of statistics has been so well developed that he is often able to draw such a conclusion to within a sufficient degree of approximation of the facts in the case, without going step by step through the actual analytical treatment of the problem.

The engineer, however, may often overlook the fact that most of our knowledge concerning the laws of nature is based on the application of the statistical method. As an example, he may not realize that the product $h\nu$ is the energy dimension assigned to the quantum of energy as a result of observations of the energy effects in each of which many quanta have been involved. In fact, so many quanta have been involved that the effect may be viewed in the light of statistical laws. Unfortunately for the seeker of truth, there is no direct road to a knowledge of the microscopic mechanism of energy or of its microscopic activities. Such things may be seen only in the light which the power of statistical analysis enables us to shed on them. But in this light it is possible to see, and that within a negligible error, just what magnitude is possible to active energy in any direction in which we may choose to follow its course. It is because the engineer is usually in the dark in the above sense that he may, for example, make assumptions concerning the microscopic behavior of radiation which, although seemingly possible, may still by the statistical analysis of the conditions be shown to be so improbable that in their macroscopic effect they can be nothing other than nil. As implied, the answer to the question, What fraction of total energy released in a combustion process may be radiated as X-rays? may be obtained through the agency of the statistical method of analysis.

The physicist, as before stated, knows that the X-ray energy must be a very small fraction of the total in this case, but even he does not know unless he has solved the problem for the conditions under consideration just how small this fraction is. In the preceding parts of this paper the method for accomplishing this has been outlined, and it has been shown, for the combustion of hydrogen to H_2O, that not more than 3.2 per cent of the total energy released in combustion may be contributed in release quota per product molecule which differ by more than 13.5 per cent from the average value of these quota. Because X-ray quanta involve approximately 1000 times the energy equal to that of the average release quota and since the release quota are the sources of energy for the quanta under consideration, the preceding statement is an answer to the question concerning the amount of energy involved in X-ray radiations. Thus it is obvious that if only 3.2 per cent of the energy may be supplied in release quota which differ by more than 13.5 per cent from the average release quota, the percentage of the energy which could be delivered in release quota of 100 to 1000 times the average must be very small indeed.

Thus the solution of the problem in question could be extended to show within limits just how much of the energy may be radiated in quanta of each of a number of different magnitudes, and so by a large number of solutions for different-size quanta a curve could be constructed to show the distribution of the radiation throughout a large range of frequencies. In effect this is what Planck was driving at, for the case of a continuous spectrum, when he developed his radiation formula. Thus, to determine the fraction of the released energy which could possibly be radiated in quanta of the X-ray magnitude it is sufficient to apply statistical Equation [4] of Part III of the paper to the energy conditions of the problem. The result shows that certainly not more than one part in ten million, and probably not more than one part in one hundred million, of the released energy could be radiated in X-ray quanta.

It follows, in so far as the energy balance of the furnace is considered, that X-ray radiations transfer but a negligible part of the total energy, and so we need make no special provisions in the heat-balance equation to take account of it. Such terms drop out of this equation. It may be shown also by the same method that the fractional part of the total energy which falls in the region of visible light waves, although larger than that which could come out as X-rays, is still negligibly small compared to the total energy involved. This leaves us with quanta in the heat-wave range as the only ones by means of which any considerable part of the transfer takes place.

Even so, the conditions of the problem have not been specified in sufficient detail for final solution of the radiation distribution of the energy involved. In order to do this it is necessary to find out how the radiation energy transfer may be distributed within the heat-wave range itself. The Planck formula used in this connection and to be discussed in the following part of the paper is, in its usual form, based, as before noted, on the existence of what is known as a continuous spectrum for whatever part of the heat-wave range it may be applied to. This implies, if the energy intensity is sufficient for the radiation or absorption of quanta of any frequency whatever, that radiations or absorption of this frequency will occur.

[1] Concluded.

[2] Sterling Professor of Mechanical Engineering, Yale University. Mem. A.S.M.E.

By definition of a true black-body radiator, this condition exists for such throughout the total range of frequencies from one to the other end of the spectrum, and under these conditions, as will be shown, the Planck formula reduces to the Stefan-Boltzmann law. But only a part of the radiating bodies in the furnace cavity approach the condition of the black body as defined above. Other bodies such as, for example, the masses of gaseous product molecules radiate in what are known as bands of the spectrum. For these the possible radiation frequencies are limited to the values within the frequency zones covered by the bands. But these bands are not continuous spectra between the two end limits of the frequency ranges which they cover. They are composed of uniformly distributed spectral lines. The spectral lines represent the radiation frequencies for which the molecules under consideration are radiating and absorbing bodies. The gaps between the spectral lines represent frequencies for which the molecules neither radiate nor absorb energy. Quanta of frequencies represented by the gaps therefore pass by such molecules, leaving them undisturbed. Schack, as will be shown later, develops the method of application of the Planck theory to this part of a radiating system.

The conditions above mentioned and still others must be considered in an application of the Planck theory to the radiation distribution within a furnace cavity, and in the following section of the paper this phase of the subject is discussed in more detail. It will finally be found that just such a treatment of the problem provides the background of some earlier papers[3] dealing specifically and quantitatively with radiation in boiler furnaces.

V—THE PLANCK QUANTUM THEORY AND ITS APPLICATION

SINCE the three foundation principles on which the macroscopic behavior of this process rests apply independently of the particular microscopical detail involved, we are at liberty to choose as the source of the radiation any convenient mechanism by means of which quanta may be emitted. Planck assumed a group of simple harmonic oscillators.

Consider again the cavity with perfectly reflecting walls. Inside the cavity we shall place a group of these simple harmonic oscillators of all natural frequencies maintained at a temperature T. Application of the second law of thermodynamics in the form stated by Kirchhoff now leads to the conclusion that when equilibrium is reached between the oscillators and the radiation inside the cavity, the mean rate of absorption of the former must equal their mean rate of emission. Hence

$$\frac{dU}{dt} = \frac{dR}{dt} \quad \ldots\ldots\ldots\ldots \text{[7]}$$

where $\frac{dU}{dt}$ and $\frac{dR}{dt}$ represent respectively the rates of absorption and emission of energy at the oscillators. From the electromagnetic theory[4] it may be shown that in general

$$\frac{dR}{dt} = \frac{2\pi\nu^2}{3c^3}\frac{\epsilon^2}{m}U \quad \ldots\ldots\ldots\ldots \text{[8]}$$

$$\frac{dU}{dt} = \frac{1}{12}\frac{\epsilon^2}{m}u_\nu \quad \ldots\ldots\ldots\ldots \text{[9]}$$

where ν = frequency of energy absorbed or emitted
U = mean energy of the oscillator of frequency ν
u_ν = intensity of energy per unit volume of frequency ν
c = velocity of light
ϵ = charge of the oscillator
m = mass of the oscillator.

Substituting [9] and [8] in [7] the result is

$$u_\nu = \frac{8\pi\nu^2}{c^3}U \quad \ldots\ldots\ldots\ldots \text{[10]}$$

On the principle of the partition of energy by the quantum theory it is assumed that an oscillator cannot have an arbitrary energy, but its energy is limited to a number of discrete values U_1, U_2, etc. The energy of an oscillator jumps from one of these values to another by a discontinuous process. The states U_1, U_2, etc. are the quantum states referred to earlier in this discussion. A quantum jump $h\nu$ must therefore be of such proportions that the relation

$$h\nu = U_{(n+1)} - U_n \quad \ldots\ldots\ldots\ldots \text{[11]}$$

holds. No transfers of energy which are subdivisions of this unit are possible to the process. Planck's work proved that, for a given frequency ν, the energy in the gaps $(U_{(n+1)} - U_n)$ is a constant. (Planck's constant h is a factor proportional to this energy.) It follows that the energy levels $U_1, U_2, \ldots . U_n$ are equally spaced. Thus, except for an additive constant, the relation

$$nh\nu = U_n \quad \ldots\ldots\ldots\ldots \text{[12]}$$

results. Equation [2] for the probability of any given energy u_e per particle then assumes the form

$$P_e = \alpha e^{-\beta(nh\nu)} \quad \ldots\ldots\ldots\ldots \text{[13]}$$

in which $1/\beta$ is again the coefficient of facility for distributing the energy $nh\nu$ possessed by the oscillator or particle. The oscillator may receive this energy in discrete units of $h\nu$, so that, as before noted, n must be an integer. These are the characteristics of radiation. As before, the probability P_e decreases for a given value of β where the energy $nh\nu$ of the particle increases, and therefore the greater the frequency ν, or the greater the value of n, the less is the chance that the eth particle or oscillator group will receive this energy from the radiation. At the same time the higher the temperature within the system, the greater is the probability for any given frequency of radiation; and therefore it is found as before that $\beta = 1/kT$.

The total number of oscillators, each of which will possess an amount of energy equal to $nh\nu$, is obviously the probability that any oscillator will possess this energy multiplied by the total number of oscillators that have any chance at all of possessing it. This means all of the N oscillators, whence

$$N\alpha\sum_n e^{-\beta(nh\nu)} \quad \ldots\ldots\ldots\ldots \text{[14]}$$

represents the number of oscillators of frequency ν. Each of these has an energy $nh\nu$, so that the total energy associated with the frequency ν is equal to

$$N\alpha\sum_n e^{-\beta(nh\nu)}\, nh\nu \quad \ldots\ldots\ldots\ldots \text{[15]}$$

This expression, except for the condition of the partition of energy on the quantum principle, is in the same form as that of the earlier Equation [3]. Thus, Equations [2] and [3] show the energy distribution on the old classical basis, and apply where the radiational influence is negligible, while the corresponding Equations [13] and [15] show the same thing on the

[3] Haslam and Hottel, Trans. A.S.M.E., vol. 50 (1928), paper no. FSP-50-3.
Wohlenberg and Morrow, Trans. A.S.M.E., vol. 47 (1925), p. 127.
Wohlenberg and Lindseth, Trans. A.S.M.E., vol. 48 (1926), p. 849.

[4] "Introduction to Theoretical Physics," by Leigh Page.

quantum basis. The former imply any number of degrees of freedom in the distribution, whereas the latter restrict it to the basis of the partition of energy on the quantum theory.

The mean energy per oscillator of frequency ν is thus [15] divided by [14], which, summed up from $n = 0$ to $n = \infty$, results in the equation:

$$U = \frac{h\nu}{e^{\beta h\nu} - 1} \quad \text{[16]}$$

This summation for different values of n corresponds to a summation over all possible quantum states; from $n = 0$ to n equals to a state of infinite energy per particle, at which, of course, the probability is zero.

Substituting [16] with $\beta = 1/kT$ in [10], Planck's law is finally obtained. Thus

$$u_\nu = \frac{8\pi \dfrac{h\nu^3}{c^3}}{e^{\frac{h\nu}{kT}} - 1} \quad \text{[17]}$$

which fits the experimental curve throughout the range of wave lengths.

The particular curves shown in Fig. 1 and Equation [17] as set up represent the energy intensities per unit volume with which the radiation is in equilibrium within the "hohlraum." Since in this the oscillators are enclosed within a shell composed of perfectly non-conducting materials, no energy escapes from the cavity. Also, once equilibrium is established, no energy is introduced into the cavity from outside sources. The picture is thus one in which the radiation process is isolated for the purpose of discovering its behavior characteristics. It is to be noted in particular that any oscillator is capable of absorbing energy of any frequency of radiation which it may emit.

The walls of furnace cavities are, of course, neither perfectly reflecting nor perfectly non-conducting, whence some of the energy of the radiation escapes through the wall itself. This results in a decrease in the temperature of the inner surface of this wall and hence in a reduction of the rate at which energy is reradiated to the oscillators from the wall. Thus there is a net radiation from the oscillators to the wall, and it is this quantity of radiation with which we are concerned. It may be shown that the equation representing this quantity differs from [17] only by a constant multiplier. Thus, combining [8] and [16], the result may be stated in the form

$$\frac{dR}{dt} = \frac{\epsilon^2}{12m} \times \frac{8\pi \dfrac{h\nu^3}{c^3}}{e^{\frac{h\nu}{kT}} - 1} \quad \text{[18]}$$

in which ϵ and m are constants. Whence, by inspection of [17]

$$\frac{dR}{dt} = \text{constant} \times u_\nu \quad \text{[19]}$$

Equation [19] states that the total rate of radiation per oscillator is equal to a constant times the energy intensity u_ν per unit volume. The total rate of radiation for all oscillators of a given frequency is thus the rate shown by [19] when multiplied by the number of active oscillators. Thus the ordinates of Fig. 1 represent to some scale the total rate of radiation as well as the energy intensity per unit volume u_ν with which the black radiation is in equilibrium.

Now the net radiation rate between the two temperatures is the difference between the total rates of radiation for each of the temperatures. Thus, in Fig. 1, this difference between 10,000 deg. K. and 5000 deg. K. and for the frequency range between ν_1 and ν_2 is represented to some scale by the area of the shaded band shown above the curve for 5000 deg. K. In particular it should be noted that in comparison to the 10,000 deg. K., that for 1000 deg. K. shows, in this range of frequencies, a negligible energy of radiation. This should not be construed as meaning that oscillators of the frequency above 1×10^{14} are not present at this temperature. It does mean that even if they should be present, the probability that at this temperature oscillators of this and higher frequencies may emit any quanta at all is exceedingly small, and therefore only very small amounts of energy are involved in comparison to what is emitted in the same frequency range for the higher temperatures.

If there is net radiation from the oscillators, their temperature may obviously be maintained only if it is compensated for from an extraneous supply, as in combustion. Net radiation from the oscillators, of course, occurs if there is a flow of energy as heat through the walls of the combustion chamber. In the case of the boiler furnace some of the oscillators are bodily carried through with the flow of gases, and hence those in transit are being continually replaced. Energy is thus carried from the cavity by gas flow as well as by radiation. The combustion obviously must supply the energy of both modes of energy discharge. The part which radiation plays in this process is a function of the frequencies and the temperature of the oscillators.

Molecules, as a matter of fact, contain a mechanism very nearly equivalent to that of simple harmonic oscillators under a few constraints. The particles oscillating in the molecules are the heavy atomic nuclei, which therefore give out and absorb quantities of energy of low frequency and their energy levels are close together. It is for this reason that the absorption lines of molecules are packed so close together as to show the appearance of bands in the spectrum.

The oscillating particles in the atom are the light electrons which vibrate with great frequency, and their energy levels are far apart so that their spectra appear as widely separated lines, the total energy involved in the radiation at a given temperature being very small indeed compared to that which occurs at the same temperature in emission or absorption from the molecules. When in molecules both the electrons as well as the nuclei vibrate, then the molecule radiates high- as well as low-frequency bands, but as before shown, the energy of the latter is not an appreciable part of the total in the energy atmosphere of the combustion process. In the first part of this paper it was proved that for all but a negligibly small part of the energy, the frequency ranges of whatever bands occur must, for the conditions investigated, be within the infra-red spectrum. In other words, they must represent heat radiations. What really happens then to the radiation characteristics of a gaseous medium when atom groups enter in combustion to form product molecules, is an increase of the number of different frequencies of radiation in the infra-red zone as the product molecule is in the process of formation.

The increase in number of different frequencies for a given number of different kinds of atoms or molecules to begin with, is thus usually a maximum when the product molecules formed have the greatest chemical complexity. Both CO_2 and H_2O radiate through three principal bands within the infra-red range, whereas the uncombined constituent gases such as oxygen and hydrogen radiate in widely separated frequency groups, and the range of frequencies covered by each group is so small that in the spectrum they appear as lines. In this sense the spectrum of carbon monoxide lies between that of CO_2 and oxygen.

Referring again to Fig. 1, let the range between ν_1 and ν_2 represent such a band. One or more such bands make their appearance when the reaction is under way. What fraction of the total radiation they represent depends on the actual frequencies

of radiation occurring within these bands, and, of course, also on the concentration of the different kinds of product molecules in the furnace gas. Thus it should be quite apparent that the Planck formula may be readily adapted to evaluate the mean of such radiation when all of the factors such as gas concentration, character of the walls of the cavity, etc. have been taken into account.

This, of course, does not mean that it will be possible in any case to evaluate the exact temperature at every part of the furnace for every instant. These temperatures depend on the history of the portion under consideration and on its rate of progress at the moment. They oscillate about some mean in both time and space. Since the Planck equations are correct in form for specifying the radiation equilibrium of each part at all times, it would theoretically be possible, by means of them, combined with the laws which govern chemical reaction, to specify in detail the immediate past, present, and immediate future states of every part of the furnace cavity. Practically, of course, such a procedure is out of the question, but we shall see how application of these equations to the statistical mean magnitudes of the conditions involved yields the best time and space mean values of the energy coordinates involved which are obtainable in the present state of knowledge of this subject.

VI—THE PLANCK THEORY OF RADIATION APPLIED TO THE CONSTANT-PRESSURE FURNACE CAVITY

Since monatomic gases are capable of radiating only in a scattered group of frequencies, and since each group covers but an exceedingly narrow range of frequencies, the fraction of the total radiation which such gases may absorb or emit is negligibly small. They are considered as playing no part in the radiation. Because gases containing molecules of two or more atoms radiate in bands of frequencies, they must be considered in the radiation as already outlined.

In solids the constraints to the oscillators are more numerous than in any gaseous molecules, so that in many cases each surface element on the solid contains oscillators having periods covering practically the entire range of frequencies included in the infra-red spectrum. Such are the surfaces known as black in the radiational sense.

Not all solid bodies present black surfaces, in that they do not absorb every incident wave whatever the frequency of this wave. But the individual oscillators at the surfaces of solid bodies, each taken by itself, have, as before shown, the characteristic behavior of the individual oscillators of the black radiation. Thus, most solid bodies absorb some waves of every frequency, the remaining ones being reflected. Refractory surfaces in the above sense are not far removed from the black surface. Coefficients of absorption for these are high, and coefficients of reflection are low.

Such surfaces are sometimes treated as gray surfaces in the radiational sense, when the Stefan-Boltzmann law is applied with the value of the coefficient reduced in proportion as the reflecting power increases. For the ordinary refractories this is usually three to ten per cent. More than 90 per cent of the incident radiant energy is absorbed at these surfaces according to the laws of radiation. The intensity of the equilibrium energy state of the molecular energy about a surface point is of course indicated by the temperature at this point. In this sense it may be said that the equilibrium temperature at a point on the surface is established when the rate of thermal reradiation from the atoms and molecules about this point is equal to the rate of absorption of radiant energy projected to the atoms and molecules about the point in question. The energy reflected at a point has no influence on the temperature at the point. However, reflected waves usually proceed but a very short distance along the path of reflection before they strike another surface point or a gas molecule which contains oscillators capable of the natural frequency of vibration required for the absorption of this reflected radiant energy. Even of the energy which is reflected at some point in its journey, only a small part ever travels the whole path from its first emission within the furnace cavity to its final absorption at the coldest surface in this cavity without intermediate stages of radiation absorption and reradiation.

Just what the exact nature of the molecular arrangement is which causes such partial reflection is not known in detail. The condition is explainable if we consider that although oscillators of every frequency are spread over this surface, at any one point oscillators of certain periods may be missing. These oscillators may be present at neighboring points where others of other natural periods may be missing. Thus at any point there would be a reflection of that part of the incident radiation which is of the frequency of the periods of the oscillators missing at this point. Consider also the fact that refractory surfaces are usually rough. The surface is but an expanse of many small

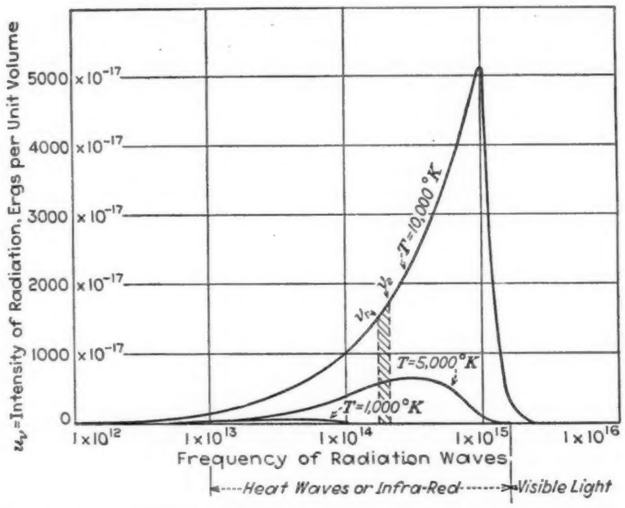


FIG. 1 INTENSITY OF RADIATION FROM A BLOCK-BODY OSCILLATOR AT VARIOUS TEMPERATURES

cavities into which most of the incident radiation strikes. That which is reflected at a point within the cavity strikes another point within the cavity itself, and therefore the chance for reflection from within the cavity is small. This explains the higher reflection coefficients of highly polished surfaces. Any reflection from a rough surface is diffuse because the reflected rays will shoot off at many different angles. Rough surfaces with a high coefficient of reflection are, for such reasons, called "white surfaces" by Planck.

SETTING UP THE RADIATION EQUATIONS FOR CERTAIN CASES

Since from [19] the total radiation rate for a given frequency of oscillator is proportional to the energy intensity u_ν, it will for a range of frequencies between ν_2 and ν_1 be equal to

$$K \sum_{\nu_1}^{\nu_2} u_\nu d\nu \qquad [20]$$

where K is a factor to be discussed later. For continuous spectra such as are illustrated in Fig. 1, the summation sign $\sum_{\nu_1}^{\nu_2}$ may be replaced by the integral sign $\int$.

Thus, to some scale, the shaded area in Fig. 1 represents this rate of radiation for a temperature of 10,000 deg. cent. abs. If Equation [20] is integrated from $\nu = 0$ to $\nu = \infty$, that is, throughout the range of frequencies, it reduces to the Stefan-Boltzmann law. This means that the total radiation rate represented by the total area under one curve as compared to that under another varies as the fourth power of the absolute-temperature values which are constant on each of the curves.

The constant K appearing in [20] is really a product $K_N K_0$. The factor K_0 is the ratio of net total radiation to energy intensity. This is the constant in formula [19], whence from [18] and [17]

$$K_0 = \frac{1}{12}\frac{\epsilon^2}{m} \qquad [21]$$

Hence, the product $K_0 \sum_{\nu_1}^{\nu_2} u_\nu d\nu$ represents exactly the total rate of radiation emitted by one oscillator for each of the frequencies covering the range between ν_2 and ν_1. Therefore, the constant K_N is the number which relates the total radiation rate for one oscillator of each frequency to the total radiation rate from the total mass or surface which contains all of the oscillators under consideration. Thus K_N at least represents the average of the number of active oscillators of each frequency taking part in the total radiation.

For solids this number is proportional of course to the extent of the area of the radiating surface. The magnitude of the number, however, may not be arrived at by a direct computation of, for instance, the number of oscillators in the surface layer per unit area, because undoubtedly some radiation is discharged through the outer layers from those near but behind this surface. How many of the layers are near the surface, that is, at a depth from which the radiation occurs, is not known. Furthermore, each succeeding layer in depth is more completely screened by those in front of it.

Even the first step in the computation, that is, evaluation of the number of oscillators per atom or per molecule, is not generally possible with reference simply to the Planck interpretation of the process. Planck's oscillators, as before shown, are ideal oscillators which do not necessarily resemble those within the atom. Thus, from the Planck point of view, we have no definite picture, in terms of atomic or molecular structure, of what we are searching for when we are asked to discover the equivalent of the number of Planck oscillators per molecule. Again the Dirac method might be employed, but, as previously noted, it would involve such a burdensome mathematical development as to leave experiment the simpler of the two methods for determining K_N. Thus from our point of view K_N has been specified for the present as completely as it may be when we say that it is a number which represents the net total of the active oscillators. Since it is proportional to the surface and since for solids the summation $\sum_{\nu_1}^{\nu_2} u_\nu d\nu$ is for a continuous spectrum from $\nu = 0$ to $\nu = \infty$, it follows that the final results of [20] may be stated in the form

$$\alpha S T^4 \qquad [22]$$

Here α is the coefficient of radiation, S the surface area, and T the absolute temperature. Obviously, the numerical value of α in this formula must be determined by experiment. It represents the number of active oscillators per unit area and is a statement of this factor translated into the language of units and dimensions used in the formula, which in turn is a statement of the relations which must hold for the variations of the conditions entering the problem.

It should be perfectly obvious that [22] is not as it stands directly applicable to the net total radiation from the total number of fuel particles in suspension in the pulverized-coal furnace. In such cases the net discharge from the particles to the walls is not directly proportional to the total extent of the surface of the particles. There is interference of some of the rays from each particle by other particles and by radiating gaseous constituents in the paths of such rays. This factor becomes quite important, especially in large furnaces, and the smaller the average particle the greater the interference fraction is for a given weight of fuel in suspension. This phase of the problem as applied to boiler furnaces has been evaluated in several papers.[3] For any particular gas constituent the number K_N involves both the concentration and thickness of the gas column, because the total number of oscillators taking part in the process increases with both of these factors. It involves the increasing interference to net radiation all through the gas column as the thickness of the column increases, because this screens some of the radiation from the oscillators. It involves then the absorption law

$$J/J_0 = e^{-K_G ps} \qquad [23]$$

which was mentioned early in the paper and in which (J/J_0) is the fraction of the initial intensity J_0 which gets through a column of gas of thickness s in which the concentration of product, i.e., radiating molecules, is p.

It involves also the shape of the gaseous body for radiation in any directions through a solid angle less than 2π. The summation $K_0 \sum_{\nu_1}^{\nu_2} u_\nu d\nu$ must be applied to each of the frequency ranges or bands of the spectrum within which the gas radiates. This is not the simple procedure it may appear to be, as some band widths change with temperature. Furthermore, as stated in the preface to this part of the paper, each band is in reality composed of uniformly distributed spectral lines. The gaps between the spectral lines are frequencies in which neither absorption nor emission of radiation occurs for the molecules in question. Band spectra of molecules are the result of a combination of the vibrational and rotational energy of the molecule. The vibrational energy determines the mean position of the bands in the spectrum and the rotational energy determines the number and position of the spectral lines within the band. The gaps between spectral lines are there because the rotational energy is quantized. In other words, the rotational energy can be changed only in definite units or by integer amounts and not in fractional parts of these units. The foregoing is a brief outline of the conditions considered by Schack in developing his formulas for evaluation of the radiating properties of gases and vapors such as CO_2 and H_2O.

The expression for K_N in its final form for the gaseous body will, like that for the solid surface, still contain a coefficient whose value must be determined by experiment. Thus, as a first approximation of the actual conditions, Schack sets up the factor K_N in the form

$$\left(1 - \frac{1 - e^{-K_G ps}}{K_G ps}\right) \qquad [24]$$

where p is the partial pressure or concentration of the constituent in question, s the thickness of the gas column, and K_G the coefficient of absorption determined by experiment. Such a factor as [24] must be combined with $K_0 \sum_{\nu_1}^{\nu_2} u_\nu d\nu$ for each of the bands of wave lengths in which the particular gaseous constituent radiates. The final form developed by Schack for the equations representing the product of form factor and K_N are not as simple as shown above. The product $K_G ps$ is a number representing

the number of active oscillators in a column of gas of unit area and of thickness or length s. Therefore, K_G is a number representing the number of active oscillators per unit volume and at unit concentration.

In concluding the discussion of this subject we may again ask why it has not been possible when starting with one atom of carbon and two atoms of oxygen which in the reaction form carbon dioxide, to set up mathematical equations directly which are sufficiently complete to specify the radiation emission and its variation in exact detail for every instant of the duration of the reaction. If this were possible we could then, theoretically at least, specify the process for each of the atom groups involved and by integration evaluate in all of its details the total radiation for any reaction. This, however, involves a complete knowledge of the mechanism and behavior of each of the individuals which enter into the process. The probability that we shall ever possess this knowledge is ridiculously small, and we shall no doubt always deal with such problems as we have here, i.e., by reference to the behavior characteristics of the crowd. Nevertheless we await with keen interest the further disclosures from the researches of the pure scientist in this field. Without doubt more knowledge of direct value to the engineer will be forthcoming, and it behooves him to make use of this to the best of his ability in order to dig from this mine what precious gold his limited facilities may enable him to use.

Air Law

THE action taken by the state of New Jersey in prohibiting the landing of seaplanes on lakes in that commonwealth is significant of the trend of development in the aeronautical industry. The matter can be viewed from several angles. One is that since the airplane has come to stay, it will be necessary for people to adapt themselves to its inconveniences, and that the next generation will regard present objections to it in the same light as we now look upon former arguments against the automobile on the grounds that it scared horses, gave off bad smells, and upset the laying habits of chickens. The unfortunate feature of this point of view is the arrogance that characterizes it, and if carried to an extreme it is likely to do more harm than good by antagonizing people who would otherwise remain neutral on the subject.

An exactly opposite view is expressed by those who look upon a seaplane as a powerful and dangerous piece of machinery which lands at a very high speed and is more or less out of the control of the pilot during the few critical seconds of landing. There have been some accidents to bystanders due to the landing of seaplanes, and even though their number has been small, the very fact of their occurrence gives colorful support to this view.

It is hardly necessary to state the views of those who occupy positions between the two extremes outlined above. It is a fact that the railroads, particularly in the early days, were a much greater menace to life, limb, and property than the airplane is today, but they came at a time when mankind was hungering for efficient transportation and was willing to make great sacrifices in order to secure it. This readiness to obtain railroad transportation at any price found expression in the granting of the right of eminent domain to railroad companies, in special legislation relieving them of certain forms of responsibility for damages, and in large monetary subsidies for the construction of their lines.

When the automobile appeared, this country in particular was well supplied with trunk-line transportation by railroads. Feeder lines were, however, entirely absent. The first automobiles were not considered a solution of the problem of by-way transportation, and were looked upon more or less as a passing fancy of people with more money than brains. The result was an avalanche of restrictive laws and practices against the automobile. When, however, the number of automobiles began to run into millions and when farmers and small-town folks began to ride in gasoline-driven vehicles, the attitude of the legislatures changed completely, with the result that today every effort is made to facilitate motor transportation, as illustrated best by the millions of dollars spent on improved highways. The same will happen to the airplane when it comes to be fully recognized as a major means of transportation.

International regulation of aerial communications is already attracting serious attention. That some agreement as to such regulation of aircraft is necessary has been powerfully brought out by Col. Chas. A. Lindbergh in his recent report on this subject. Aircraft, because of their great speed, are destined to become means of communication over long distances, and obviously they will be flown (in Europe far more than here) from one country to another and possibly over the territory of a third, as is already the case in flying from Paris to Warsaw.

In the United States, in so far as domestic flying is concerned, a much more important subject is the question of state vs. federal regulation of aeronautics. At present the whole subject is in a chaotic state. The Department of Commerce has been given power to regulate flying within certain limits. The necessity for such regulation is so broadly recognized and the Department of Commerce has apparently been handling it in such a fair spirit that the regulating law has not been seriously tested as to its validity and constitutionality. There is no question, however, that this is so only because thus far Federal regulation has not injured any one sufficiently to make a test worth while. Such was the case in the first year after the formation of the Federal commission for controlling radio broadcasting. As soon, however, as the Radio Commission took steps which were considered harmful to the business of some of the broadcasters, a number of suits to test its power were instigated.

As far as aeronautics is concerned, Federal regulation is essentially limited to interstate commerce, and as long as flying is primarily an interstate business, this may be sufficient. When, however, the number of fliers increases and intrastate communications develop, state regulation will become imperative, and from all indications the states are not in a mood today to surrender their regulating powers in any field to the Federal Government.

It is not so much a conflict of the regulating powers of the states and the Federal Government that is to be feared as it is the fact that the differences in regulations in the various states may impose an additional and unnecessary burden on the manufacture of airplanes.

The American Society of Mechanical Engineers has clearly recognized this situation in another field, namely, boiler construction, and its Boiler Code has powerfully contributed toward the creation of uniform regulations as to boiler construction and operation throughout the country. This was accomplished by first creating a standard boiler code acceptable to the industry and the engineering profession, and then forming a society for the promotion of adoption of uniform legislation covering the operation and construction of boilers throughout the country. Why would it not be a good plan to do something along the same lines in the matter of creating a uniform code of laws governing construction and operation of airplanes in the 48 states of the Union?

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The Argus As 8 Aviation Motor

THIS motor took the high honors in the "Round Europe Flight" in the summer of 1930. The one here described is primarily designed for use in sport planes and is rated at a continuous output of 80 hp. It is an air-cooled engine with the cylinders in line, but contrary to the usual practice the cylinders are suspended. The weight has been set at 112 kg. (246.8 lb.) for cylinders of 120 mm. (4.72 in.) bore and 140 mm. (5.51 in.) stroke, and the output of 80 hp. is obtained with a piston velocity of 6.5 meters (21.32 ft.) per sec. and an average pressure of 8.2 atmos. (117 lb. per sq. in.) In addition to certain technical advantages, the suspended arrangement of the pistons provides

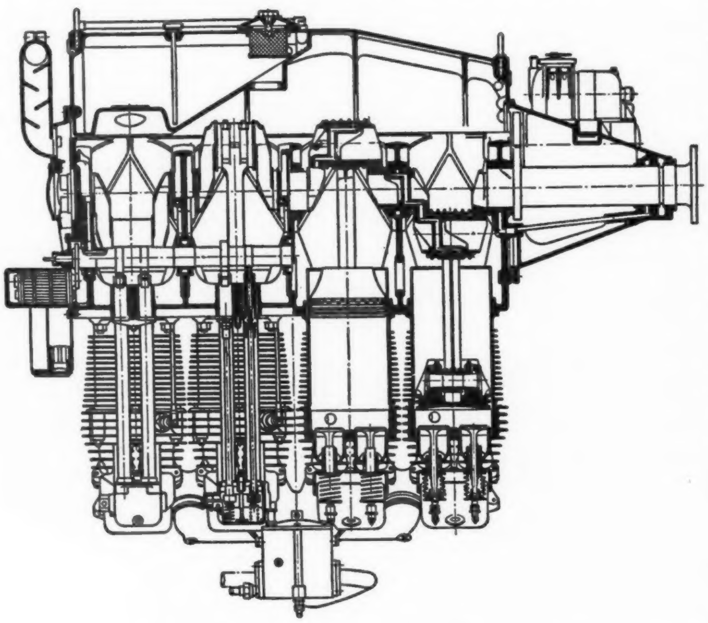


Fig. 1 The Argus Aviation Motor With Suspended Cylinders

good visibility and reduced air resistance together with increased accessibility. The motor is shown in longitudinal section in Fig. 1. It is equipped with a six-bearing crankshaft and an ignition magneto located near the airscrew. The oil pump is driven by a gear from the camshaft. The cylinder construction is of steel with aluminum heads and pressed-in valve seats. In order to reduce the weight of the motor, several unusual arrangements have been adopted. Thus, for example, the lubricating-oil supply is kept in the cover of the crankcase, which provides enough oil for 6 hr. of flying and yet eliminates special oil containers and their piping. The crankcase is so strongly built and provided with such reinforcements that the motor can be suspended from it without special devices. The piston velocity of 6.5 meters (21.32 ft.) per sec. must be considered low as it corresponds to a motor speed of 1400 r.p.m. and gives a "mechanical velocity" ω^2N (where ω is the angular velocity and N the output in horsepower) of 1,730,000 hp. per sec. per sec., which compares favorably with such values as 2,800,000 and 6,400,000 for similar motors having speeds from 1800 to 2200 r.p.m. With this "mechanical velocity" the peripheral velocity of the airscrew remains also within limits which produce moderate centrifugal stresses, wear, and noise.

The crankshaft is an Elektron casting. The oil container in its cover holds 8 liters (2.11 gal.) of lubricating oil and vents into the crankcase, thus eliminating losses of oil. This oil is delivered to the right places by means of a triple-gear pump driven through a gearwheel from the end of the crankshaft and entirely enclosed. Two of the pump sections serve to take care of the complete elimination in all positions of the plane of oil collecting in the crankcase about the cylinder liners. This oil is returned to the oil container after passing through a screen. The third section of the pump takes the oil from the container, passes it through a filter screen, and then delivers it to the pipes leading to the various bearings of the crankshaft.

The camshaft bearings are lubricated by oil forced through the hollow camshaft. The oil gets to the connecting-rod bearings through holes bored in the crankshaft and inserts in the crankshaft holes made of Elektron castings, and finally all the other parts that need lubricating are supplied with oil which is projected by centrifugal force.

The original article reports tests of the motor and shows that on the test bench it ran with an average speed of 1434 r.p.m., an average output of 83 hp., and an average fuel consumption of 0.217 kg. (0.478 lb.) per hr. (W. Kamm, Stuttgart, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 74, no. 41, Oct. 11, 1930, pp. 1409–1412, 6 figs., *d*)

The "R-101" Disaster

THE article here abstracted discusses the history of the airship and emphasizes the fact that it was purely and simply an experiment. Its heavy-oil engines, as a matter of fact, do not appear to have been a very successful experiment as they developed torsional oscillations which later were somewhat reduced but were never entirely overcome.

The design of the airship itself was materially affected by the lessons obtained from two other previous disasters: the *R-38* in England and the *Shenandoah* in the United States. The *R-101* was constructed in full knowledge of the causes which had wrecked the *R-38* and the *Shenandoah*.

"Her early trials," the article continues, "proved that she was capable of executing a sharp turn at high speed. She had never encountered a serious vertical current, but there is not much possibility for doubt that, in at least her original condition, the allowance made for such an event was ample. In support of that statement, it may be said that the *R-100*, designed to the same general strength specification, encountered and survived unhurt a severe vertical current toward the end of her outward voyage to Canada. Yet in spite of all the care, knowledge,

skill, experience, and foresight which went to the making of the *R-101*, the vessel has failed as suddenly, and, for the moment, as inexplicably, as any of her forerunners. Is it possible that once again scientific inquiry, wise as always after the event, will establish some hitherto unsuspected factor as the cause? Is it possible that, if it does, men will be found bold enough to urge once again that the airship should be given another chance? With a heavy heart, we are constrained to answer both questions with a "Yes." It would be against our convictions, but not against our wishes, if we answered that the disaster to *R-101* will assuredly mark the end of the airship. She was an experiment. The experiment has failed, but how near was it to success? We do not know, and may never know. It is, however, certain that when the shock of Sunday's catastrophe has become dulled by time, arguments will be advanced justifying, or attempting to justify, the continuation of the experiment. Some trifling cause, some minor error of judgment or execution, not some omission of a major scientific fact, may be the explanation of the disaster. If such proves to be the case, is it conceivable that the experiment will be permanently abandoned? We cannot believe it. We cannot hope that science, taking it and all the lamentable previous occurrences of its kind, will turn from finding an excuse for them, and instead use them to prove that the major and minor factors affecting airship construction and operation are so numerous, so complicated, and so much influenced by chance, as to leave the ambitions of their advocates outside the reach of practical realization." (Editorial in *The Engineer*, vol. 150, no. 3900, Oct. 10, 1930, pp. 401–402, *g*)

INTERNAL-COMBUSTION ENGINEERING (See also Aeronautics: The Argus as 8 Aviation Motor)

The Hesselman Oil Engine for Motor Vehicles

THIS is a high-speed oil engine developed by K. J. Hesselman, of Stockholm, a well-known engineer. In this case the compression ratio is only 5.5 to 1, and hence does not differ materially from that of standard engines. In order to obtain ignition with such low pressures, Hesselman uses spark plugs of the ordinary type, together with a rotary motion of the air about the axis of the cylinder, obtained by screening off on one side the intake valve. Toward the end of the compression stroke finely atomized fuel is slowly injected into this rotating air stream, and this injection is done in such a manner that the part of the air flowing past the spark plug is sufficiently saturated with fuel and is therefore easily ignited. The beginning and end of this part of the injection process must be so timed with reference to the spark at the spark plug that the spark actually occurs at an instant when the air carrying the fuel flows past it. As a result of this it becomes necessary that when the amount of fuel is changed the rotating velocity of the air shall likewise be changed. This is obtained by throttling in the suction piping when the amount of fuel to be injected is reduced. This method of running the engine is particularly suitable for idling. As the load increases, more and more fuel is injected into the rest of the air circulating in the cylinder and not necessarily passing directly over the spark plug.

The most important advantage of this method of operation is that it can be installed on evaporation-type motors of the usual kind without producing excessive pressures and decreasing the output of the motor. An illustration in the original article shows a four-cylinder motor which has been altered to suit this process by changing the cylinder blocks, attaching a special camshaft for driving the pumps, and installing a different piston made of light metal. This motor was installed on a three-ton truck, and for a considerable period of time has given excellent satisfaction. In a motor specially designed for this process the camshaft for driving the fuel pumps can be connected to the one operating the valve gear. In designing machinery for the new process it is assumed that the mist of fuel injected into the cylinder will, at extended idling or low outside temperature, be prevented from settling on the cylinder walls and eventually running down into the crankcase. To do this the piston, Fig. 2, is provided in its upper part with a ring *a* which at the

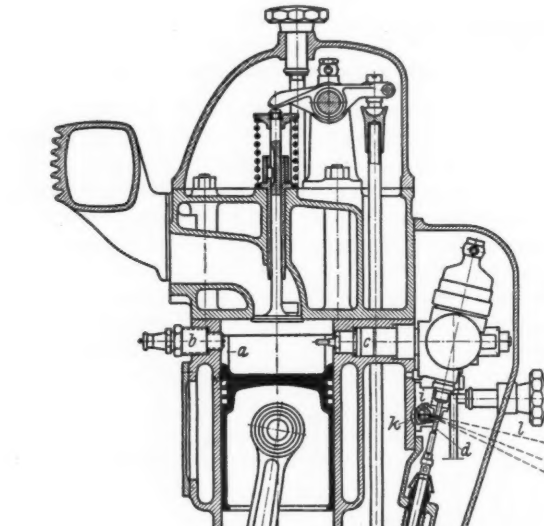


FIG. 2 THE HESSELMAN HIGH-SPEED OIL ENGINE FOR USE ON MOTOR VEHICLES

end of the compression stroke practically completely closes in the combustion space on the sides, and has only two slots—one for the spark plug *d* and the other for the fuel nozzle *c*. The spark plug in its slot is protected against direct access of fuel to the terminals. At idling the ignition is further assisted by the fact that in the rotating air stream pronounced turbulence is produced when the air passes the spark plug. This is obtained by beveling one edge of the slot in the piston near the spark plug in a direction opposite to that of the bevel at the other end. The fuel nozzle gives two jets, both of which take a somewhat horizontal path in the combustion space. As a result

of this the finely atomized fuel strikes surfaces which, when the engine is running, are hotter than the cylinder walls. After a certain period of operation these surfaces become covered with a thin layer of carbon deposit, which facilitates combustion and in any event can do no harm. Each of the fuel pumps (shown in some detail in the original article) is directly connected to its own nozzle. This is done in order to avoid what is referred to in ordinary engines as unequal manifolding, where some cylinders get less fuel than others because of the greater length of the path. The injection pumps receive the fuel from another pump. As regards the regulation of fuel for various outputs of the engine, it is stated that one of the conditions that must be satisfied is that the cessation of the fuel delivery must be constant. To do this the pump piston working against the spring always opens a valve at the end of its pressure stroke, permitting the fuel to flow into the pump housing and therefore cutting off its delivery into the cylinder.

The engine is started by an electric starter with the injection of a small amount of gasoline into the suction piping. The purpose of this injection is to obtain a higher speed of the engine at the start than can be given by the electric starter. No injection is necessary when the engine is warm.

It is claimed that recent tests in Stockholm have shown that when operating on gas oil of about 0.86 specific gravity, the engine starts from cold without smoking and can be rapidly accelerated to a high output. It is also claimed that in operation the performance of the engine does not differ materially from that of an automobile engine of the usual type. Even when idling for a considerable time, the pistons do not cool down sufficiently to affect the combustion and produce a smoky exhaust.

The original article gives curves obtained in tests carried out in Stockholm. (Dr. Techn. A. Heller in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 74, no. 28, July 12, 1930, pp. 970–972, *dA*)

ELECTRICAL ENGINEERING

The "Kosfi-Leading" Compensation Induction Motor With Power-Factor Correction

THIS is a motor built by the English Electric Co., in London and designed to give any power factor from unity to 0.5 leading, the variation being secured by rocking the commutator-brush gear.

The "Kosfi" motor does not operate normally as a synchronous motor, as in the case of the synchronous induction motor, but is a compensated induction motor which is not liable to drop its load until the maximum stalling torque is reached. In this machine the functions of the stator and rotor of the ordinary induction motor are reversed, in that the rotor becomes the primary to which the power is supplied, and the stator the secondary winding. The rotor, in addition to having the normal winding of the wound-rotor machine, carries a winding connected to a commutator having brushes spaced around its periphery. To these brushes the stator winding is connected through suitable starting resistances.

A case is cited of a metal works with a load of 400 kva. and a power factor of 0.65 lagging. New compressors were being installed, and two 75-b.hp. "Kosfi-Leading" motors, with a power factor of 0.7 leading, were used to drive them. One of the motors was, however, employed to drive a d.c. generator used for lighting and welding purposes, as this was found a better proposition. As a result, the power factor of the system was increased to 0.93 lagging, and a saving effected of approximately £20 per month in the power bill. (*The Iron and Coal Trades Review*, vol. 121, no. 3260, Aug. 22, 1930, p. 260, *d*)

MOTOR-CAR ENGINEERING (See also Internal-Combustion Engineering: The Hesselman Oil Engine for Motor Vehicles)

The Gillett Automatic Clutch and Free Wheel

IN THIS case a conventional motor-car transmission unit has been combined with the free wheel and an automatic mechanism controlling the clutch. Only two pedals are required, one being the accelerator and the other the brake pedal.

To start the car the low gear is engaged by means of the usual central lever without touching any other control. The accelerator pedal is then depressed and as the engine picks up, the clutch comes into action automatically. When the car is on the move the process of changing up to a higher gear consists of releasing the accelerator pedal, pausing an instant, and then shifting the gear lever rapidly into the required position. A clutch stop which quickly reduces the speed of the spinning parts accounts for the rapidity with which gear changes can be carried out. The system also provides for coasting when the throttle is closed.

In the mechanism a normal friction clutch and a conventional gearbox are retained unaltered. The additions consist of a free wheel behind the gearbox, a clutch stop, and a device controlled by the accelerator pedal which operates the clutch automatically when the throttle is closed.

The free-wheel mechanism used on the car described in the article is said to be of a somewhat novel type, consisting of an expanding spring of square section, which, when caused to uncoil slightly, exerts great pressure on the surrounding casing and conveys the drive in this way. Mounted on the engine there is a control box upon which depends the automatic operation of the ordinary friction clutch. The withdrawal gear of the clutch is pulled toward the disengaged position by a strong coil spring, and a force is exerted in the reverse direction by a pull rod operated from the control box. The motive power is derived from a piston and cylinder in the box supplied with oil from a pump connected to the lubricating system of the engine. A detailed description of the device is given and illustrated in the original article. (*The Motor*, vol. 58, no. 1497, Sept. 2, 1930, pp. 189–190, illustrated, *d*)

Spark Plugs

A NEW spark plug has been developed by the engineers of the Graham-Paige Company. It is claimed that while this plug is "hotter" in design, it eliminates preignition troubles and also reduces fouling. Tests made by the company have shown that it is not the porcelain but the center electrode that causes preignition. By increasing the size of the shell and helping the flow of heat by such means, for example, as replacement of the asbestos-copper gasket by a solid copper gasket, the temperature of the center electrode was reduced, which eliminated preignition. Next, an effort was made toward reducing fouling of the plugs. It was found that this could be done by projecting the center insulator far into the combustion chamber and counteracting the heating which this part brought about by still better means of heat conduction and dissipation. Both metric and $^7/_8$-in. plugs have been developed.

Insulators were projected as much as $^9/_{32}$ in. beyond the end of the shell, using the longest or so-called "hottest" insulator available, intended for low-speed, low-compression engines. True enough, a point was finally reached where the end of the insulator apparently became hot at the same time as the metal parts, but in no case before. The explanation seems to be that the incoming charge exerts a cooling influence on the electrodes and insulator, and while heat-flow capacity is lost by lengthening

and extending the insulator, the cooling action of the intake gases is increased. A point is finally reached where the two effects balance.

The final findings with the $^7/_8$-in. plug have resulted in a design in which a long insulator is used, extending approximately $^3/_{16}$ in. beyond the end of the skirt. With this the short-projection center electrode, the thick-wall shell, and the solid copper gasket are used. This plug can be run indefinitely with a 5.5 compression ratio, using 5 deg. excess spark advance, without causing preignition trouble, and at the same time it is infinitely harder to foul under any conditions, first, because the end of the insulator operates at a higher temperature than previously, and secondly, because it is gas-swept in the combustion chamber, resulting in its tip or end remaining white and free from black soot under conditions that would foul former types of so-called "hot plugs" so they would not fire. (F. F. Kishline, Asst. Ch. Engr., Graham-Paige Motors Corp., in *Automotive Industries*, vol. 63, no. 11, Sept. 13, 1930, pp. 376–378, 2 figs., *de*)

PETROLEUM ENGINEERING

The Use of a Boiler-Feedwater Heater With Steam-Powered Rotary Drilling Equipment

IN THE past the generation of steam for drilling operations has usually been accomplished by the use of portable locomotive-type boilers, as the plant had necessarily to be of a temporary design. However, with the constantly increasing depth to which oil wells are being drilled and the use of larger and heavier equipment the steam requirements have reached a point where equipment and methods of permanent-plant type can be and are being used to a decided advantage by the more progressive operators. In this case the boiler-feedwater heater becomes a valuable adjunct to the steam-generating equipment in view of the large quantity of steam necessary for deep drilling.

The following conclusions are arrived at from the investigation carried out jointly by the U. S. Bureau of Mines and the state of Oklahoma.

The use of boiler-feedwater heaters lowers drilling costs by effecting an economy of 10 to 15 per cent in fuel requirements and of 20 to 25 per cent in water consumption, increased the boiler-horsepower capacity of the boiler 10 to 16 per cent, lengthens the life of the boilers, decreases the maintenance costs of the boilers, reduces the lost time for boiler repairs, and lessens the danger of boiler failures. Their use also muffles the sharp exhaust from the pumps and engines, and carries the steam away from the derrick. The value of this feature cannot be expressed in dollars and cents, but lies in the fact that it creates better and safer working conditions. The hazards of steam-engine exhausts are discussed by H. C. Miller in his paper, "Safeguarding Workmen at Oil Derricks," Bull. 272, Bur. of Mines, 1917, pp. 100–101.

Boiler-feedwater heaters are practical where the steam demands are large, when the supply of water is limited, or when fuel is expensive. They are of particular value for deep drilling, where large quantities of steam are required, and for "wildcat" locations where fuel and water are very expensive or difficult to obtain. It is not uncommon for a water shortage to delay drilling operations, and in such cases the use of feedwater heaters would have the effect of increasing the water supply 20 to 25 per cent.

In a drilling campaign where 100 deep wells are to be drilled, an approximate saving of $100,000 in fuel and water and an additional saving of about $50,000 in maintenance costs on the boilers would be obtained by the use of boiler-feedwater heaters. This conclusion applied to conditions and expenses similar to those in the Oklahoma City field.

The open-type boiler-feedwater heater and condenser is better adapted and more practical for oil-field service than the other types of feedwater heaters. Its advantages are simplicity of design, low cost, ease with which scale can be removed, high temperature of the feedwater, and the high recovery of condenser water. (C. E. Reistle, Jr., Petroleum Chemist, U. S. Bureau of Mines Petroleum Experiment Station, Bartlesville, Okla. in *Report of Investigation No. 3022*, 14 mimeographed pages, 5 sheets of drawings, *ep*)

POWER-PLANT ENGINEERING (See also Petroleum Engineering: The Use of a Boiler-Feedwater Heater With Steam-Powered Rotary Drilling Equipment)

A Super-Lancashire Boiler

AROUND 1923 Daniel Adamson & Co., Ltd., put down two Lancashire boilers of their own construction with a working pressure of 260 lb. Such a working pressure for a Lancashire boiler was unheard of at the time of the installation.

The complete unit comprises a boiler 20 ft. long × 8 ft. 6 in. in diameter, a superheater, air heaters, and a induced-draft fan direct coupled to a small high-speed engine and a forced-draft fan. The steam is used for turbines on the test plate.

The boiler is constructed along the general lines of the ordinary Lancashire type with regard to plate thickness and general manufacturing details, but the internal flues are rather smaller in diameter than in common practice, and they are constructed with the Daniel Adamson anti-collapsible flange combined with special absorber rings. The boiler is hand fired and the products of combustion pass through the main internal flues at approximately normal speed. At the back end of the boiler is a metal-encased firebrick-lined downtake chamber which is specially constructed to eliminate eddies in the gas. The superheater is housed on the top of the downtake and is constructed of a solid-drawn steel tubes. The design of the superheater is such that the drop in pressure of the steam during its passage from inlet to outlet is small. In the official test this drop in pressure was only $^1/_2$ lb. when passing 8087 lb. per hr. at a pressure of 138 lb. with an average superheat of 320 deg. fahr.

After the gases leave the flues of the boiler, they enter the downtake chamber and take a downward curved movement, passing through and around the outside of the superheater loop tube elements; they then pass through the nests of tubes connected with the back and front ends of the boiler and below the internal large main flues. The gases passing through these tubes at high velocity impart the heat by convection, at a rapid rate; the high velocity of the gases also serves to keep the tubes free from dust deposits.

As a consequence of the combined medium velocity of the gas through the main internal flues and the high velocity through the small tubes, a large proportion of the useful heat of the fuel is given up to the water in the boiler, with, of course, a corresponding reduction in the temperature of the gases leaving the boiler. The gases then pass outwardly to left and right, in two streams approximately equal, through special chambers, in which are provided accessible tube-hole stoppers made so that they may be opened when the boiler is under steam, to enable the tubes to be examined or cleaned.

The boiler with its auxiliaries forms a complete and independent unit, and is very accessible for examination, no brick settings being required; in fact, it is only the downtake chamber which is lined with brickwork, thus eliminating the possibility of losses

due to defective brickwork and air leakages. The connection between the boiler and the metal-encased downtake is provided with a patent flexible air-excluding device. The downtake chamber is arranged with access doors, also cleaning-out doors and inspection sight holes, the whole being surrounded with a gangway lying between the top of the superheater and the forced-draft fan and chimney. The air preheaters and downtake are carried on a concrete base, the first named resting on cast-iron chairs.

The official test was made by the National Boiler and General Insurance Co., Ltd, on March 13, 1930. The details are given in the original article. The net overall thermal efficiency was found to be 83.31 per cent. The boiler was worked with approximately only 40 per cent of excess air. The combustion was so good that no smoke was emitted from the chimney. (*The Iron and Coal Trades Review*, vol. 121, no. 3260, Aug. 22, 1930, pp. 258–259, 2 figs., *d*)

The Municipal Diesel Plant at Hudson, Mass.

THIS article is of interest as it compares several methods of obtaining power and gives detailed figures for the Diesel engine. After such a comparison it was decided to install the following equipment:

Two 900-b.hp. 8-cylinder, 4-cycle, air-injection McIntosh & Seymour engines with 615-kw. General Electric Co. generators direct-connected.

One 675-b.hp., 6-cylinder, similar engine direct-connected to a 460-kw. generator.

The cost of the change-over from steam to Diesel was as follows:

Building changes, fuel oil tanks, crane, and craneway...	$ 12,800
Pumps, piping, and auxiliary equipment...............	4,300
Electrical work......................................	4,700
Diesel engines, generators, exciters, and foundations complete..	145,200
	$167,000

Of this amount, $160,000 represents plant investment and $7000 represents alterations in the existing plant. The change-over was financed by taking $127,000 from the construction fund, made up from the surplus earnings of the previous six years, and the remainder from a bond issue of $40,000 bearing interest at $4^1/_2$ per cent and to be repaid in ten annual payments of $4000 each.

Comparative steam and Diesel operating costs are given in detail in the original article. It is claimed that these show the gain in efficiency and economy of a typical Diesel plant over an ordinary steam plant, and a saving of $30,000 a year by the installation of the Diesel plant, or enough to pay for the installation cost in five years.

This system of generation has enabled Hudson to promulgate practically the lowest average rates in Massachusetts.

In 1926 the rates were:

For Domestic Lighting and Commercial Lighting

First 100 kw-hr. per month.........	9	cents per kw-hr. net
Next 300 kw-hr. per month.........	8.1	cents per kw-hr. net
Next 400 kw-hr. per month.........	7.2	cents per kw-hr. net
Next 700 kw-hr. per month.........	6.3	cents per kw-hr. net
All over 1500 kw-hr. per month.....	5.85	cents per kw-hr. net

For Domestic Power

3 cents per kw-hr.

For Commercial Power

First 500 kw-hr. per month........	4.05	cents per kw-hr. net
Next 1000 kw-hr. per month........	3.6	cents per kw-hr. net
Next 1500 kw-hr. per month........	3.15	cents per kw-hr. net
Next 2000 kw-hr. per month........	2.95	cents per kw-hr. net
Next 2500 kw-hr. per month........	2.7	cents per kw-hr. net
All over 7500 kw-hr. per month.....	2.475	cents per kw-hr. net

In October, 1929, the following present rates were instituted:

For Domestic Light and Power

First 20 kw-hr. per month.........	7	cents per kw-hr. net
Next 180 kw-hr. per month.........	3	cents per kw-hr. net
All over 200 kw-hr. per month......	2	cents per kw-hr. net

For Commercial Lighting

First 20 kw-hr. per month........	7	cents per kw-hr. net
Next 80 kw-hr. per month........	6	cents per kw-hr. net
Next 700 kw-hr. per month........	5	cents per kw-hr. net
Next 1200 kw-hr. per month........	4	cents per kw-hr. net
All over 2000 kw-hr. per month.....	3	cents per kw-hr. net

For Commercial Power

First 300 kw-hr. per month........	4	cents per kw-hr. net
Next 1700 kw-hr. per month........	3	cents per kw-hr. net
Next 2500 kw-hr. per month........	2.7	cents per kw-hr. net
Next 3500 kw-hr. per month........	2.4	cents per kw-hr. net
All over 8000 kw-hr. per month.....	2.2	cents per kw-hr. net

Cooperative Wholesale Rate Demand Charge

First 100 kw. of 30-min. demand................	$2 per month
Over 100 kw. of 30-min. demand................	1 per month

Energy Charge

First 2 hr. use of demand...............	2.5	cents per kw-hr.
Next 3 hr. use of demand...............	2.0	cents per kw-hr.
Next 3 hr. use of demand...............	2.75	cents per kw-hr.
Next 3 hr. use of demand...............	1.5	cents per kw-hr.
Next 3 hr. use of demand...............	1.0	cents per kw-hr.
Over 14 hr. use of demand..............	0.8	cents per kw-hr.

These represent reductions of about 30 per cent to 50 per cent for domestic use, 30 per cent to 40 per cent for commercial lighting, and 5 per cent to 12 per cent for commercial power.

The author gives reasons why Diesel-powered plants of the size under consideration are so economical.

The old bugbear against operating Diesels in a first-class neighborhood has been entirely removed. The exhaust can be so silenced that it is inaudible over 50 ft. from the station, and cork mats under the foundations do away entirely with vibration. Because of the absence of coal dust, ashes, and smoke, the stations can be and frequently are made very handome architecturally and set admidst beautiful surroundings, the buildings often resembling banking institutions or high-class administration buildings, a credit to their surroundings. (Leland D. Wood, Manager, Light and Power Development, Hudson, Mass., in *The American City*, vol. 43, no. 2, Aug., 1930, pp. 87–89, 2 figs., *d*)

RAILWAY ENGINEERING

The Holmes Locomotive Poppet-Valve Gear

THE use of poppet-valve gears in locomotives has been increasing steadily during the last few years. As to the Holmes gear, it is claimed that it gives perfect timing for all valve positions and up to 84 per cent cut-off, the cut off being infinitely variable and not limited to a series of steps. Other advantages are claimed for it, such as that it is controlled and reversed in the simplest possible manner, and is little affected by wear.

The principle of operation can be followed by reference to the drawings reproduced. In Fig. 3 the rotating cam A which is keyed to the half-speed camshaft B swings the oscillating cams C by means of two bellcrank levers D (with arms offset) and slide block E through 90 deg. and back, twice in each camshaft revolution, that is, once per engine cycle. The fulcrums of the levers are carried between two members F, called the fulcrum carrier, and it is the partial rotation of these members which controls reversing and varies the cut-off. To increase

the period of admission, the fulcrum carrier is turned in the same direction as that in which the camshaft is revolving. This has two effects:

1 It delays the action of the rotating cam on the lever.

2 It turns the long arm of the lever through an angle, thus turning the oscillating cam through an angle relative to its own center. The latter effect has in turn two effects:

a It brings more of the lift portion of the oscillating cam into such a position as to act on the valve, thereby increasing the period of opening.

contains only four cams, one rotating (*A*) and two oscillating cams (*C*, *C*) for steam admission, and one cam (*G*) for exhaust. The valves are placed at 45 deg., i.e., 90 deg. to one another, which corresponds to 180 deg. of the axle. Tappets are provided between the cams and the valves to take the side thrust of the cams. The fulcrum carrier *F* is duplicated and the two parts carry the fulcrum shafts *H* and their levers *D* between them. Two stays *J* connect the two parts rigidly to one another.

Both exhaust valves are operated by one double-ended cam *G*,

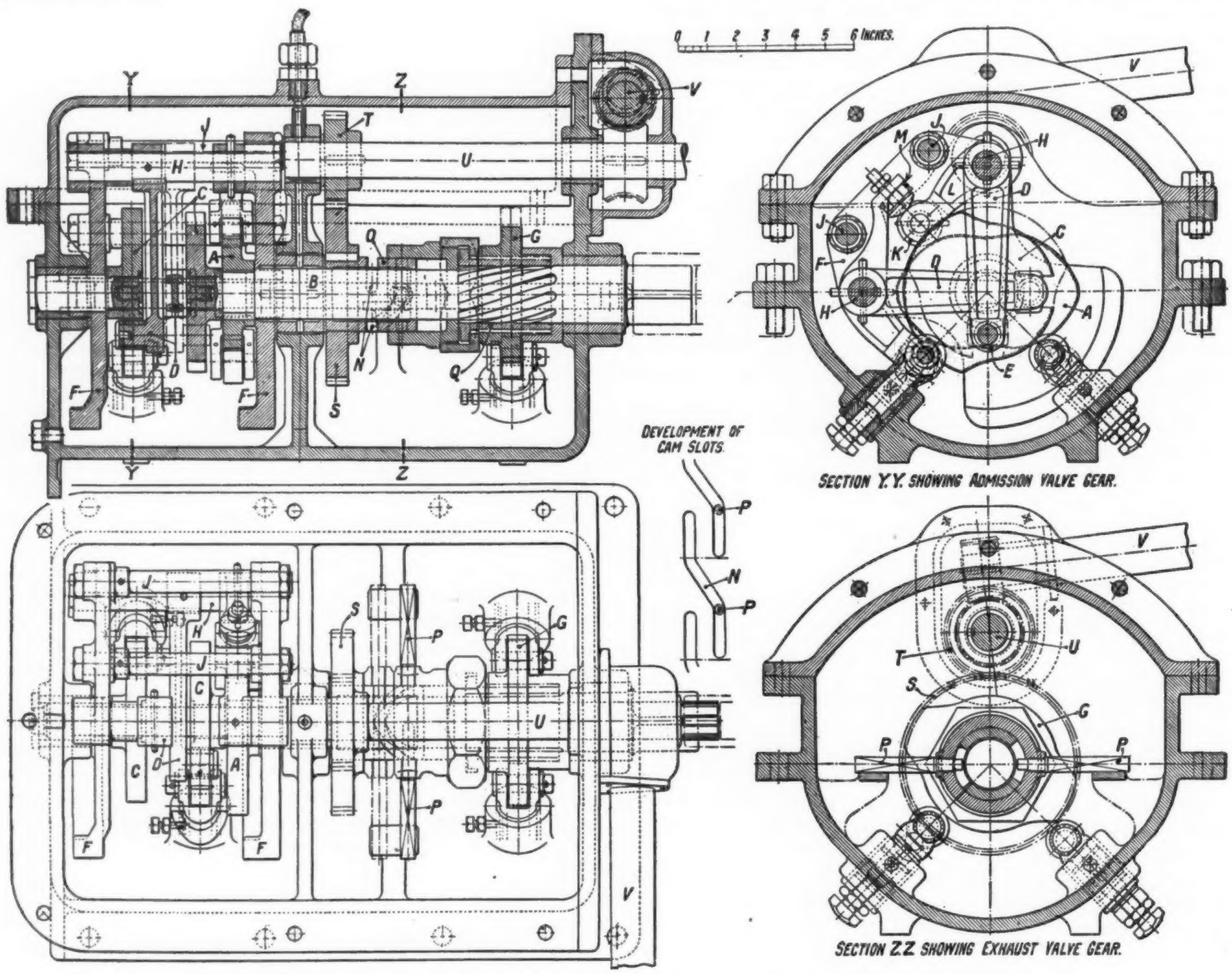


FIG. 3 GENERAL ARRANGEMENT OF CAMSHAFT DRIVE FOR THE HOLMES POPPET-VALVE GEAR

b It brings the opening point on the cam nearer to the tappet roller, so that it acts on it earlier in each oscillation.

The effects (1) and (*b*) are made to neutralize each other, since (1) is a delaying effect, and (*b*) is an advancing effect, so that the opening of the admission valve takes place at the same point in the cycle for any cut-off—in other words, the lead is constant. If, however, it is thought desirable to vary the point of opening slightly, for instance, by reducing the lead in full gear to insure easy starting, this can be achieved by modifying the contour of the rotating cam.

Reversing is effected by turning the fulcrum carrier through 90 deg. from the point of minimum opening to steam, in a direction opposite to the original camshaft rotation.

Fig. 3 shows the complete valve gear for application to a locomotive. It will be seen that the entire gear for one cylinder

means being taken also to reset this cam properly automatically when the engine is reversed. In the design shown in Fig. 3 the exhaust-valve timing is constant, but if desired it can be varied slightly. Because of the small number of cams required they can be of reasonably large size, which makes for greater accuracy of timing than is obtainable in small cams.

The lift of the cam can be multiplied by levers if desired, and with this arrangement full opening to steam can be obtained with 25 per cent cut-off. The cam box is comparatively small, measuring only $18^3/_8 \times 12^7/_8 \times 12^3/_8$ in. outside, and can be easily withdrawn for inspection or replacement. Reversing and control of cut-off are effected by the partial rotation of the fulcrum carrier as explained in detail in the original article.

The valves themselves follow standard practice. (*The Railway Engineer*, vol. 51, no. 608, Sept., 1930, pp. 355–357, 2 figs., *d*)

The Froelich Hydraulic Car-Retarder System

An INSTALLATION of this kind has been made at the Whitemoor Yard of the London and North Eastern Railway, in England, but there are already several installations of the kind in Europe. The installation is semi-automatic.

When the train arrives on one of the receiving tracks, a switchman walks along the train, uncouples the cars, and makes out what is termed a "cut card." On this card are indicated the numbers of the cars which have to be run off on to the respective classification tracks. The cut card is sent by pneumatic tube to the control cabin, and the operator, on receipt of this, is able, by manipulating certain levers on the switch table, to store up the route movements electrically, in a drum on the floor below. The cars, in passing down the hump and through the retarders, automatically set the points for succeeding cars, this being done by means of track circuits, in accordance with the routes previously stored in the switch drums. Four-aspect color-light signaling, at the top of the hump, has been adopted to indicate the speed at which the cars must be humped, while in foggy weather klaxon horns are utilized, the operation then being governed by sound signals.

In the event of any special cars passing over the hump, or other circumstance arising of which the yardmen should be informed, a megaphone is used from the control tower. The foreman's cabin at the top of the hump is in telephonic communication with the cabin at the entrance to the receiving yard, and with the control cabin; the foreman, from his position at the top of the hump, is able to exercise a general jurisdiction over the entire operation. The yard is illuminated at night by means of floodlight projectors.

Electric motors situated in the basement of the control tower drive the pumps generating hydraulic pressure for working the retarders, and heating pipes are provided underneath these retarders to prevent freezing in severely cold weather.

The provision of these retarders, together with the new method of operating the switches leading from the hump to the classification yards, has speeded up the classification to such an extent that a train of 70 cars, with from 40 to 50 cuts, is classified in 7 min., the sequence of the movements over the hump being much quicker than can be undertaken with safety in a yard dependent solely upon brakemen for the application of the brakes on the cars to regulate the speed.

Detail cards taken from a typical day's work are shown in the original article. In a shift of eight hours 1369 cars were classified, this involving 962 cuts. A diagram of the control machine is given in the original article.

Having described the various methods by which trains are prepared on the tracks, it will be of interest to note the procedure adapted in connection with their departure from the yard. At the point where the 40 classification tracks converge to form the two departure tracks, there is an inclined brake siding or "kip" with connections to both departure tracks. All the cabooses of trains which arrive at the receiving tracks are worked through the yard and placed as opportunity arises on the kip, which will accommodate 15 cabooses. The kip is constructed with a gradient sufficiently steep toward the departure to enable a caboose, when released, to run by gravity to the rear of the train. As soon as the conductor arrives in the yard he is given the number of the engine that is to haul the train, the particular caboose that is to be attached to the rear of it, and the number of the track from which it is to be drawn. He thereupon proceeds to the track, and examines and attaches the requisite number of cars. The engine is coupled up as soon as it arrives from the roundhouse, and the conductor signals to the switchman that the train is ready to be drawn into the departure track to attach the caboose. This is done as quickly as possible, and as soon as the last car of the train is drawn clear of the brake-kip points, the caboose is released and runs to the rear of the train, the latter then being ready to accept the signal for the main line. As the train is being drawn through the departure tracks, which are approximately 560 yd. in length, the signalman controlling the outlet is advised of its approach so that he may release it with a minimum of delay.

The many different types of wheels and tires in use in England offer a problem in designing and constructing the retarders so that all shapes and sizes can be suitably retarded. Certain

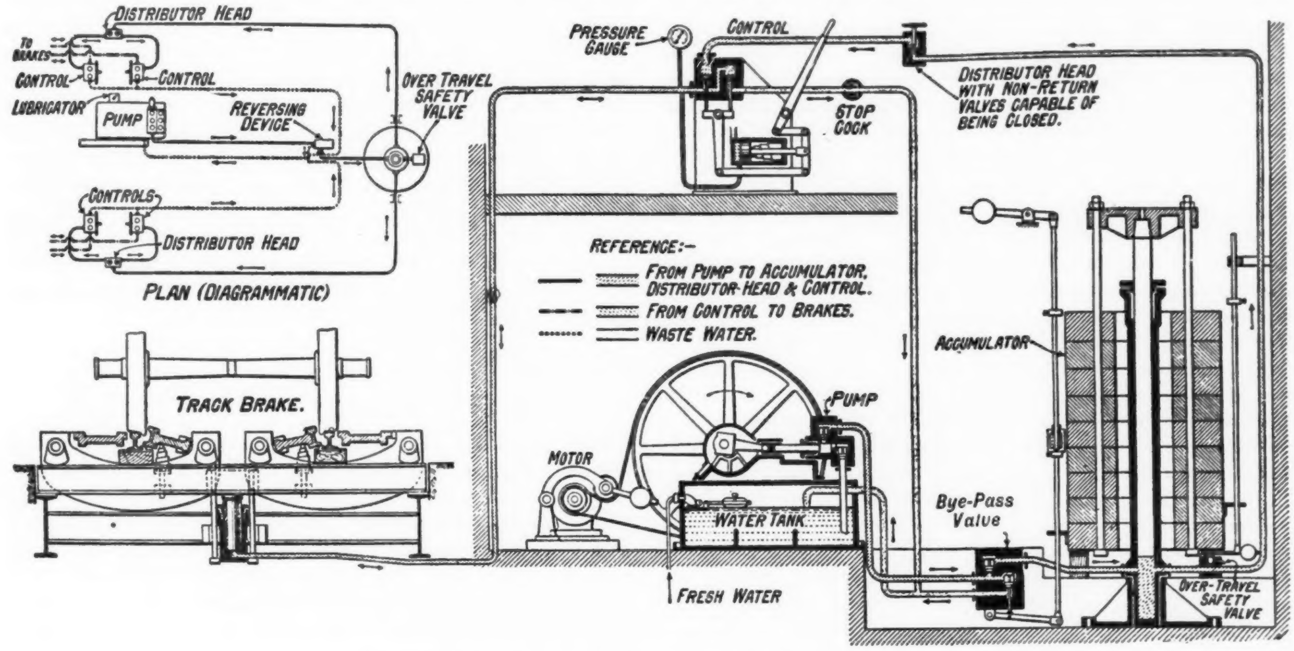


Fig. 4 Diagram of the Hydraulic and Braking System

adjustments are still being made at Whitemoor in this respect. Unfortunately, there is a small proportion of cars on which the tires are secured to the wheel centers by means of bolts, and these cannot be handled by the retarders, but are passed through the retarder in the non-braking position and into track No. 31, which is provided especially for these cars. At present, therefore, additional men have to be employed for braking purposes, but this difficulty is receiving careful consideration. At the entrance to the receiving yard a device has been installed to detect and indicate such wheels as are fitted with projecting fastenings that make retarder control impossible.

Aside from this difficulty with certain wheels, little trouble has been experienced. Lack of uniformity in the thickness of the wheels has little effect on the retardation. The number of axles, also, has no influence on the braking efficiency.

There are four retarders, located on the four main ladders leading to the classification tracks; they are operated by four control levers in the control cabin. The retarders each consist of a table which can be raised and lowered by means of several hydraulic cylinders. Dr. Froelich's "weight automatic" principle is one of the important technical features, and insures that the weight of the car will automatically establish and control the braking effect while the car is passing through the retarder.

The understructure, which is about 50 ft. long and 10 ft. 4 in. wide, rests in a concrete pit, and carries the running rails, which are of B.S.R. 90-lb. flat-bottom sections. This understructure is supported by the hydraulic cylinders, which are placed longitudinally in the center. Each cylinder is fitted with a piston which carries a cross-beam and in turn supports two cradles. These cradles, carrying the retarder rails proper, are free to move sideways, being provided with rocking segments for this purpose. Of these rails, the outer one is fixed rigidly to the cradle and the inner one is pivoted in such a manner that when hydraulic pressure is applied to the cylinders, the cross-beam, and with it the cradles, rises to a maximum height which brings the top of the braking rails about $4^3/_4$ in. above the level of the running rail and alongside the car wheels.

It will thus be seen that if the retarder rails are raised in this manner when a car is passing through, the foot of the inner retarder rail is raised until it meets the flange of the wheel, and any further pressure forces the head of this rail against the inside flange of the tire, bringing the outer retarder rail against the other side and thus providing the desired degree of retardation.

If the pressure is still further increased, the car will simply be lifted off the running rail, and will continue to run on the flanges of its wheels, which are wedged between the braking rails, the maximum retardation being then in force. This precludes the possibility of derailment. The downward thrust causes the inner and outer brake rails to function as a toggle joint, causing pressure to be exerted on either side of the tires.

The hydraulic pressure is obtained from a reservoir which is housed in the basement of the control cabin and charged by a special triple-throw hydraulic pump driven by a 20-hp. motor. Between each retarder and its respective control handle there is only one pressure pipe. The pressure applied to the retarder is regulated by the control handle. The maximum hydraulic pressure which can be applied to the cylinders of the rail brakes is about 1400 lb. per sq. in., which, working on a $5^{29}/_{32}$-in. piston, is sufficient to raise the heaviest car from the running rails, thereby subjecting it to the maximum retardation.

The control handle can perhaps best be described as a spring-loaded automatic pressure-relief valve, and its method of working is as follows: By moving the lever across its quadrant the pressure is admitted to the pipe leading to the brake and the latter is raised to the full extent. The position of the lever sets the pressure at which the release valve will lift, in such a manner that if the handle is, say, only halfway across when the car enters the retarder, a certain amount of water is released back through the control valve, which results in the table falling somewhat and applying half the maximum retardation. If, however, the handle is pushed completely over, and consequently no water is released by the valve, the retarder rails remain in the highest position and the maximum retardation is applied.

The operation of the switches is, as already intimated, partly automatic and partly non-automatic. All switches are controlled by one man at a switch table in the control cabin. The switch motors operate on 110 volts d.c., the collector-drum circuits on 36 volts, and the track circuits on 12 volts.

The first seven switches, that is to say, the three between the hump and the retarders, and the four immediately following the retarders, are automatically operated by reason of the cars shunting the track circuits and relays. The movements of the automatic switches having been set up prior to the shunting of the train, by means of the eight route levers situated in the front of the switch table, the classification of a complete train proceeds rapidly and without interruption.

The position and length of the track circuits are somewhat critical, being of necessity in the nature of a compromise. The effective length is about 38 ft., which is divided into two parts, one of 13 ft. ahead of the switch point, and one about $22^1/_2$ ft. behind it. The fixing of the total length at 38 ft. precludes the possibility of using a car the distance between axles of which is more than 38 ft. If it were longer it would reduce the speed at which switching could be done. (*Railway Signaling*, vol. 23, no. 9, September, 1930, pp. 329–334, illustrated, *dA*)

REFRIGERATION

A Direct-Expansion Quick-Freezing Machine

THIS system has been recently designed by C. L. Ashley and A. V. Rudd, of St. Louis, Mo., and is an elaboration of a principle employed in the packing industry for a long time, but is said to possess certain special advantages. These have been obtained by enclosing the chilling medium, thus making it possible to use primary refrigerants in direct expansion. The refrigerant enters the freezing chambers as a liquid, in which state it is maintained at a level of a little more than three-quarters the height of the drum. As it absorbs heat from the products which are being frozen, it boils off as a gas, rises to the top of the container, and escapes, while fresh liquid is automatically admitted through the control valves to maintain the predetermined level.

Instead of relying on sensible heat to chill the food products, the introduction of a primary refrigerant enables this machine to make use of the latent heat, and it is claimed that the fact that the refrigerant cannot escape until it has changed its state from a liquid to a gas is a further assurance of the thermal efficiency, as it cannot turn into a gas until it has absorbed a definite amount of heat.

The machine consists essentially of a hollow drum rotating on a horizontal axis and partially surrounded by a stationary chilling tank. The refrigerant is expanded into both the drum and the chilling tank and maintained, in a liquid state, at predetermined levels, by means of automatic control valves. Foodstuffs to be frozen are placed on the surface of the drum, and as the rotation carries them into the freezing chamber, which is formed on one side by the stationary chilling tank and on the other side by the drum itself, lids for holding the food parcels in place are automatically closed and adjust themselves to the thickness of the product. These lids hold the food parcels firmly against the drum surface throughout the freezing period, so that re-

frigeration is applied by direct contact on one side and by radiation and conduction through a small air gap on the other side. When the frozen foodstuffs emerge from the freezing chamber at the end of the chilling period, the covers trip open and the products drop out on to a conveyor. The process is continuous and semi-automatic, the only labor required being that necessary to place the unfrozen parcels on the surface of the slowly revolving drum.

Preliminary investigations indicate that a steak three-fourths of an inch thick will be frozen in about twenty minutes when the drum temperature is maintained at—55 deg. fahr. The speed of the drum may be increased or decreased, to accommodate existing conditions. (H. G. Miller in *Ice and Refrigeration*, vol. 79, no. 2, Aug., 1930, pp. 128–129, 1 fig., *d*)

The Carba Dry-Ice Process

THIS process was invented in Switzerland for the manufacture of solid carbon dioxide. Its chief feature consists in the expansion of liquid carbon dioxide through a special needle nozzle at the "triple point" pressure of 5.28 atmos., whereby the freezing point of carbon dioxide is reached. Part of the liquid carbon dioxide is in this manner converted into moist, plastic snow, which, by reason of the kinetic energy with which it leaves the nozzle, is tightly pressed together, and by the subsequent further expansion down to atmospheric pressure, is solidified into a compact block of high specific gravity. The size of the block is controlled by gaging the time of forming the snow. The operation of the process requires a specially constructed nozzle in which the expansion is first carried slightly below the "triple point." The nozzle is not described in detail, however.

In comparing previous methods of production with this, it may not be out of place to call attention to another interesting phenomenon in the Carba process. By the expansion of the boiling liquid, it is brought to a definite temperature (the triple point). Further expansion within certain limits brings about subcooling or supersaturation: that is, the vapor is colder than the saturation temperature of the pressure attained, or the pressure is greater than the saturation pressure corresponding to the temperature attained. The formation of snowflakes, or crystals, takes a certain time, and it is not known whether the period of expansion in a short jet or nozzle, which under the usual conditions can occupy only the thousandth part of a second, is long enough to allow this. Similarly, the conduction of heat into the interior of the drops and into the interior of the wet mass must occupy an appreciable time.

A drop of definite size and temperature, in surroundings of equal temperature, is in thermodynamic equilibrium only if the vapor pressure exceeds the increase in saturation pressure caused by capillary attraction.

The velocity of flow of a frozen drop, or a flake of snow, is equal to that of its enveloping gas only at its moment of formation; rather it is smaller, since the drop is carried along as a foreign body by the friction of the somewhat accelerated gas. It is thus evident that a correct nozzle for expanding CO_2 to produce snow must possess a definite length, so that the time during which heat is flowing from the liquid drops to the cold gas which surrounds them may be increased. If this precaution is neglected, the snowflakes are formed first in the free stream of gas and the crystals are deposited in the generator in a finely divided state, but if the nozzle is given a length of about 400 mm., the flakes congeal in the nozzle itself, and the more or less frozen droplets enter the generator in a cylindrical jet. The final product, which is produced by this specially designed and patented nozzle, is a plastic mass of snow which is already more or less crystalline in form and possesses great density. It is evident, too, that the whole process of expansion must follow the pressure curve, since the expansion takes place without the production or expenditure of work. (*Cold Storage*, vol. 33, no. 389, Aug. 21, 1930, pp. 243–244, 2 figs., *d*)

THERMODYNAMICS

Calculation of Oil Temperatures of Oil Coolers

THE author has particularly in mind oil coolers of the class employed to cool the oil used in lubricating turbine bearings. The first to derive a formula for such coolers, in particular

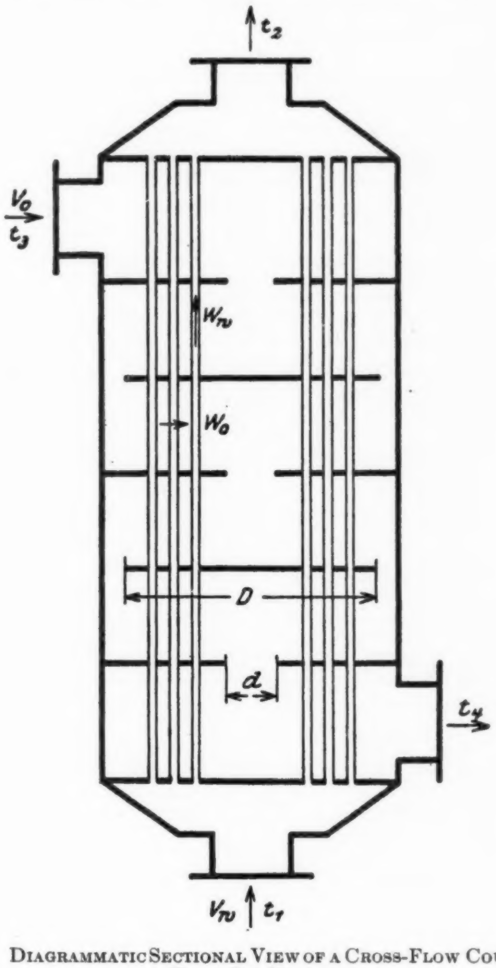


FIG. 5 DIAGRAMMATIC SECTIONAL VIEW OF A CROSS-FLOW COUNTER-FLOW OIL COOLER

for the cross-flow counter-flow type (i.e., the type where the water flows through the tubes and the oil flows around the tubes crosswise to them and in the direction opposite to the flow of water), were E. Heinrich and E. Stueckle, who derived for these coolers the following equations:

$$k = 200\,(w_w \times w_0 \times t_m)^{0.3}$$

$$k = 185.6\,(w_w \times w_0 \times t_m)^{0.3}$$

The meanings of the symbols used in the above equations and throughout the article are as follows:

V_w = flow of water in liters per min.
V_o = flow of oil in liters per min.
w_w = $\alpha_w V_w$ = velocity of flow of water in meters per sec.
w_0 = $\alpha_0 V_0$ = average velocity of flow of oil in meters per sec.

t_1 = water inlet temperature in deg. cent.
t_2 = water outlet temperature in deg. cent.
t_3 = oil inlet temperature in deg. cent.
t_4 = oil outlet temperature in deg. cent.
t_m = $\frac{t_3 + t_4}{2}$ = average oil temperature
F = area of cooler in square meters
Q = quantity of heat transmitted in large calories per hr.
γ = specific weight of oil in kg. per cu. dm.
c_p = specific heat of oil in calories per kg.
k = coefficient of heat transmission
α = constant in the expression for the coefficient of heat transmission.

Fig. 5 shows diagrammatically a cooler in which for the sake of clearness the central pipes have been omitted. The constants α_0 and α_w depend only on the transmission surfaces for oil and water, which can be determined according to the formulas of Heinrich and Stueckle. Assuming that $c_p = 0.415$ and $\gamma = 0.896$, and assuming further that the product $60\ c_p\gamma = 22.3$ is constant, it will be found from the heat given up by the oil that the oil temperature is

$$t_3 = \frac{Q}{22.3\ V_0} + t_4 \qquad [1]$$

The cooling-water exit temperature can be found from the amount of heat taken up by the water (provided the losses by radiation are neglected):

$$t_2 = \frac{Q}{60\ V_w} + t_1 \qquad [2]$$

The error due to assuming that $c_p\gamma$ is constant is very slight. From the equation of heat transfer in counter-current flow given in the original article the author by substitution obtains the following equation for the cooler:

$$\frac{y}{x} \log \left(\frac{Qz}{t_4 - t_1} + 1 \right) = (B + t_4)^{0.3} \qquad [6]$$

In the above equation y is constant for a given cooler. The

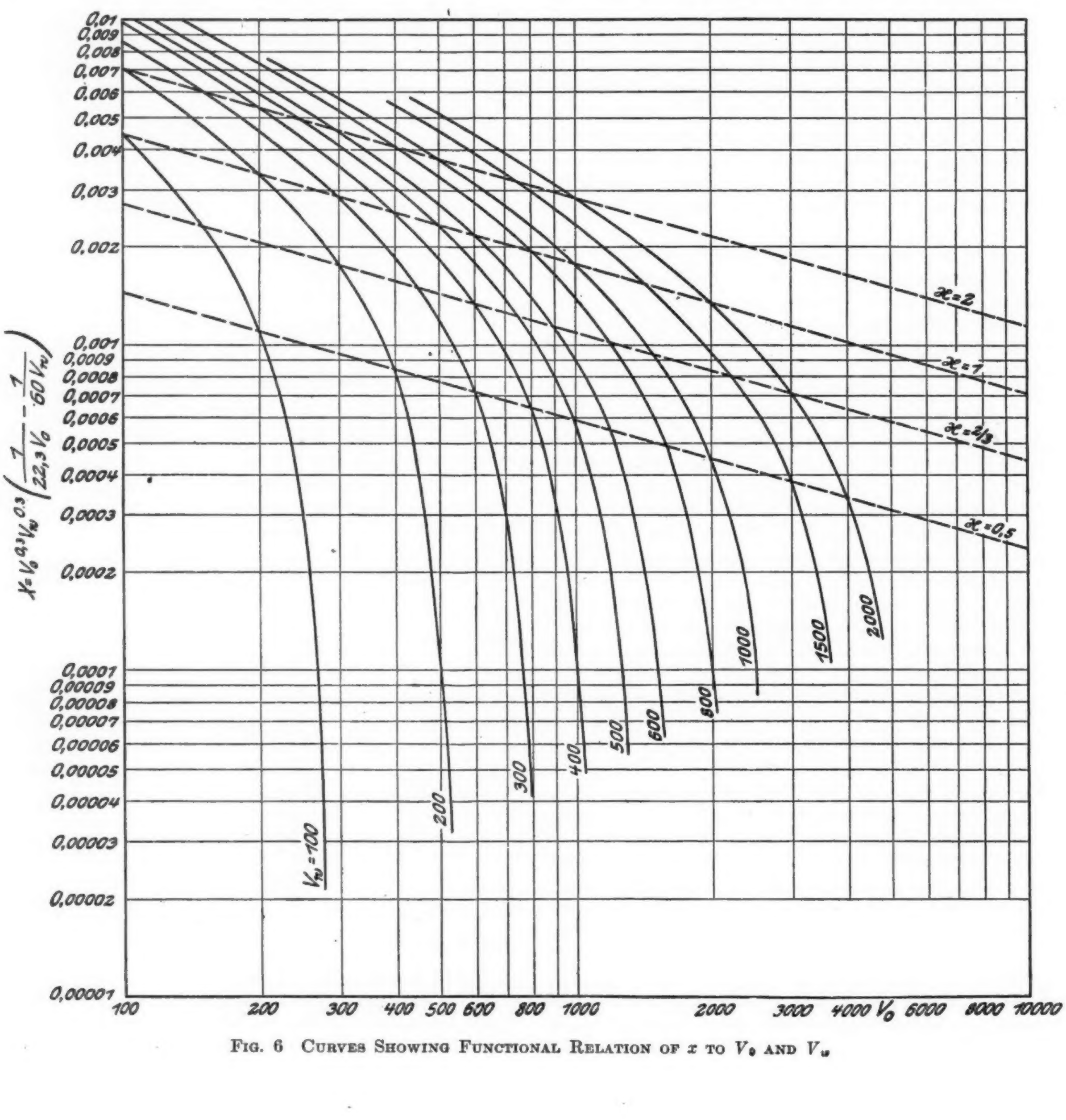


FIG. 6 CURVES SHOWING FUNCTIONAL RELATION OF x TO V_0 AND V_w

values of x and z are then dependent only on the quantities of oil and water. B is dependent only on the amount of heat exchanged and the amount of oil present, assuming always that $c_p\gamma$ is constant.

In the majority of cases the amount of heat flow Q, the cooling-water temperature t_1, and the amount of oil present V_0 are given. The cooler constant y is known through the selection of cooler dimensions. If then a value is assumed for a certain quantity of water V_w, the oil exit temperature t_4 will be the only unknown value in Equation [6]. Unfortunately, however t_4 cannot be directly determined from this equation, and it becomes necessary to solve the equation graphically. To do this Equations [7] and [8] are used.

$$\frac{y}{x}\log\left(\frac{Qz}{t_4-t_1}+1\right)=\rho \qquad [7]$$

$$(B+t_4)^{0.3}=\rho \qquad [8]$$

If the two curves are plotted on a single diagram as functions of t_4, the intersection of the two lines will give the desired value of t_4. The oil inlet temperature is then determined from Equation [1] and the water outlet temperature from Equation [2].

To facilitate calculations Figs. 6 and 7 give sets of curves from which the values for x and z for given quantities of V_w and V_0 can be read directly. The cooler constant y is supposed to have been determined once for all for each kind and size of cooler, and as a result the values of the symbols in Equation [6] can be directly inserted from the tables and diagrams without any intermediary calculations.

Influence of Variable Operating Conditions

The influence of the quantity of water on the operation of the cooler may be expressed as a function of the quantity of oil, which gives

$$V_w=\kappa V_0 \quad \text{and} \quad z=\frac{1}{V_0}\left(\frac{1}{22.3}-\frac{1}{60\kappa}\right)$$

The value of z becomes a maximum when $\kappa = \infty$, passes through zero value for $\kappa = 22.3/60$ or roughly 3/8, and becomes negative for $\kappa < 22.3/60$. Since the value of z is also contained in x, the value of x changes in a manner similar to the above. If the lines for the constant κ (as has been done for certain of these values) be plotted in the diagrams for x and z, it will be

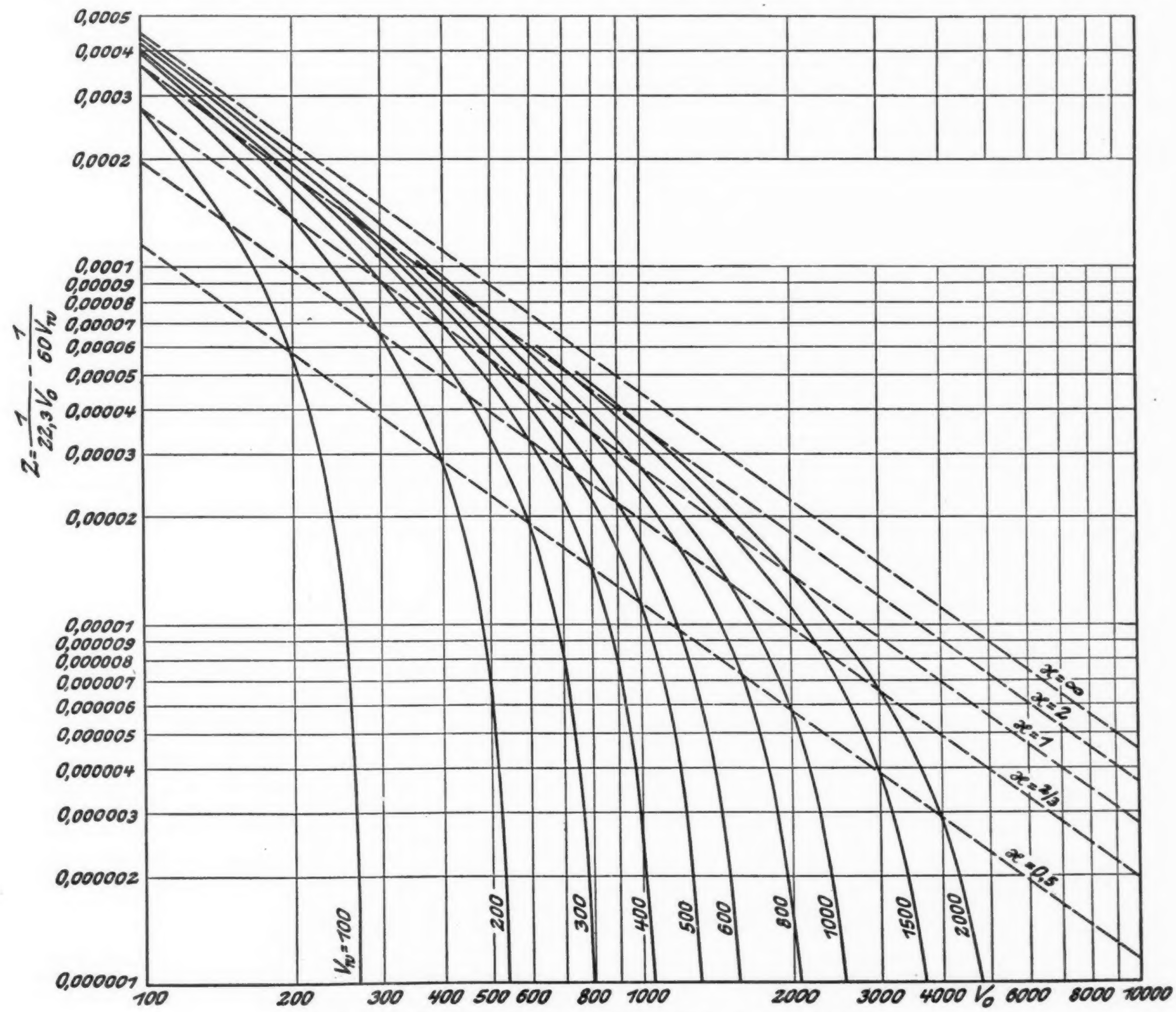


FIG. 7 CURVES SHOWING FUNCTIONAL RELATION OF z TO V_0 AND V_w

found that a variation of κ is of practical importance only within comparatively narrow limits. Another material increase in κ beyond 3 gives therefore only a slight improvement in the operation of the condenser; on the other hand, however, a reduction of value of κ below 1 produces a rapidly increasing reduction in the efficiency of the device.

At first glance the cooler equation does not show this influence of the quantity of flowing water. It does show, however, that z appears as an element of addition in the logarithm, and hence as long as $\kappa < 22.3/60$, z is also positive but exerts a much smaller influence than x. The curve plotted in accordance with Equation [7] will therefore lie higher as x becomes smaller or κ is selected smaller, provided values of ρ are ordinates and of t_4 are abscissas.

Equation [8], however, is independent of κ, but the higher the first curve is located, the further is the intersection of the two lines in the diagram shifted toward the right, which means that the higher will be t_4. Since the heating of the oil is independent of the quantity of cooling water, t_3 rises so that it always remains a given amount beyond t_4.

The author discusses next the case where $\kappa < 22.3/60$ and x and z become negative, and comes to the conclusion that the quantity of cooling water should not be too small, but that its material increase does not help very much. An upward limitation of the amount of cooling water is also set by the fact that for economic reasons the water resistance in the cooler should not be too great.

A variation in the amount of oil produces essentially the same effect as a variation in the amount of water. On the other hand, the oil temperatures fall off uniformly, when, under otherwise similar conditions but with constant value of κ, the amount of oil increases, which is equivalent to increasing the quantities of oil and water but leaving the amount of heat transfer the same. From the diagrams of Figs. 6 and 7 it appears that when κ is constant and the amount of oil increases, the values of z decrease a great deal faster than the values of x. The logarithm of Equation [7] increases faster than y/x, so that the curve sinks much lower, while the curve for Equation [8] sinks but very little. As a result the intersection of the two moves to the left, which means that the oil temperatures fall off and t_3 falls off faster than t_4. The variation alone of the quantity of heat being exchanged produces similar results, as this is merely a reverse of what has been described above. Furthermore, because of the higher viscosity of the oil the resistance of the cooler increases much faster on the oil side, with the result that the amount by which the quantity of oil may be increased very rapidly reaches its economical limit.

As stated above, the influence of variation of the specific heat and specific weight of the oil is not important, as the author shows by calculation.

Rating

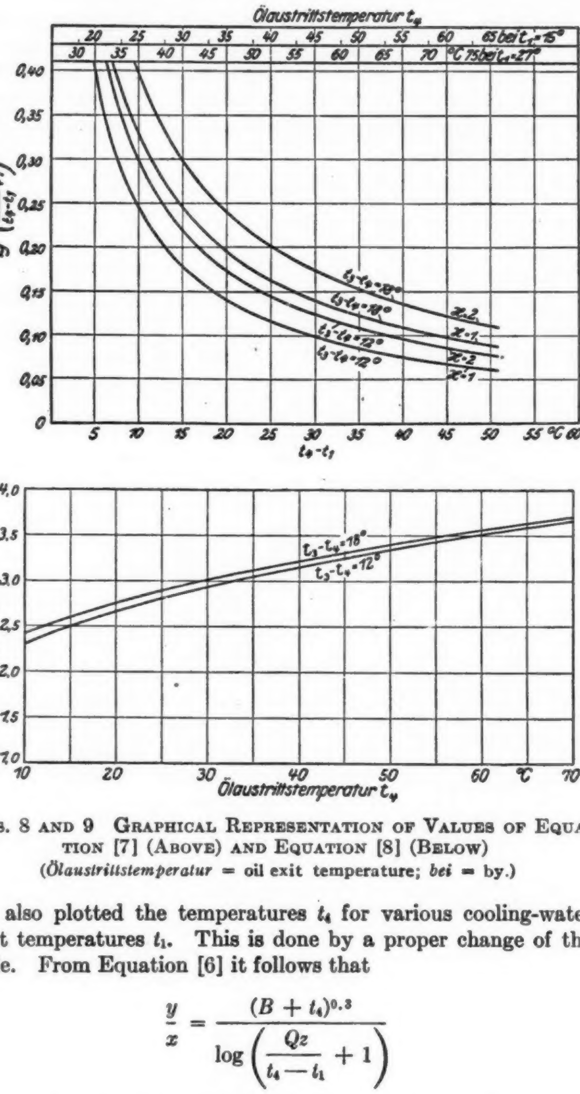
Equations [6], [7], and [8] may be conveniently used for rating oil coolers. From Equation [1] the heat content of 1 liter of oil is found to be $Q/V_0 = 22.3\ (t_3 - t_4)$. If it be assumed that $t_3 - t_4$ is constant, then Qz in Equation [7] will be also constant, provided κ remains constant, which will lead to

$$Qz = \frac{Q}{V_0}\left(\frac{1}{22.3} - \frac{1}{60\kappa}\right) = \left(t_3 - t_4\right)\left(1 - \frac{0.327}{\kappa}\right)$$

Furthermore

$$B = \frac{Q}{V_0}\frac{1}{44.6} = \frac{1}{2}\left(t_3 - t_4\right)$$

If we now plot a curve with $t_4 - t_1$ as abscissas and the logarithms of Equation [7] as ordinates, we shall obtain as in Fig. 8 curves expressing the functional relationship of κ and $t_3 - t_4$, and what is more, these curves are good for all coolers. In a second diagram, Fig. 9, the values of Equation [8] are plotted against the oil exit temperature and show the relationship to $t_3 - t_4$. These curves likewise apply to all coolers. In Fig. 8



FIGS. 8 AND 9 GRAPHICAL REPRESENTATION OF VALUES OF EQUATION [7] (ABOVE) AND EQUATION [8] (BELOW)
(*Ölaustrittstemperatur* = oil exit temperature; *bei* = by.)

are also plotted the temperatures t_4 for various cooling-water inlet temperatures t_1. This is done by a proper change of the scale. From Equation [6] it follows that

$$\frac{y}{x} = \frac{(B + t_4)^{0.3}}{\log\left(\dfrac{Qz}{t_4 - t_1} + 1\right)}$$

The values for the numerator and denominator are taken from corresponding curves plotted for the same value of t_4 in Figs. 8 and 9. The values so obtained are plotted on the curves as a function of the oil inlet temperature t_3 in accordance with Equation [6]. As a result of the limitation of the quantity of oil and water in the cooler imposed by the resistance to flow, there is for each cooler a predetermined value of V_0, while κ may be varied within narrower limits. y is a constant of the cooler, and hence y/x for each cooler depends only on κ. In the original article the author gives a fairly complicated expression for x in terms of V_0 and κ, and shows how from Equation [6] it becomes possible to calculate for various operating conditions the oil inlet temperature and to determine thereby the oil and water outlet temperatures. To do this he gives a table of values for t_1 equal to 15 deg. and 27 deg. cent. (Ch. Engr., P. Danninger, Görlitz, in *Elektrizitätswirtschaft*, vol. 29, no. 511, July 1, 1930, pp. 325–330, 6 figs., *pA*)

Instruments and Apparatus

Preliminary Draft of Part 9—Heat of Combustion

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 9, "Heat of Combustion," of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, and E. B. Ricketts.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (8 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Materials, (6) Electrical Measurements,[4] (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition (4 chapters), (11) Determination of Quality of Steam,[5] (12) Time Measurements, (13) Speed Measurement,[6] (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations,[8] and (21) Leakage Measurements (2 chapters).[9]

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

TABLE OF CONTENTS

[1] See pamphlet published June, 1928.

[2] Chapter 1 of Part 2, on "Barometers," was published in pamphlet form June, 1929.

Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in pamphlet form, June, 1929.

[3] Chapter 1 of Part 3, "General," was published in the December, 1925, issue of Mechanical Engineering.

Chapter 5 of Part 3, on "Pyrometric Cones," was published in the August, 1930, issue of Mechanical Engineering.

Chapter 6 of Part 3, on "Glass Thermometers," was published in the April and May, 1926, issues of Mechanical Engineering.

Chapter 7 of Part 3, on "Pressure-Gage Thermometers," was published in the October, 1928, issue of Mechanical Engineering.

[4] See Mechanical Engineering, December, 1928.

[5] See Mechanical Engineering, June, 1930.

[6] See Mechanical Engineering, April, 1929.

[7] See Mechanical Engineering, March, 1930.

[8] See Mechanical Engineering, November, 1930.

[9] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form, November, 1928.

Description and Classification

1 This part treats of calorimetric apparatus for solid, liquid, and gaseous fuels. Constant-volume or oxygen bomb calorimeters are used for solid and liquid fuels, and constant-pressure or flow calorimeters are used for gases.

2 The heating value of solid, liquid, and gaseous fuels is usually required for one of two purposes: either as a basis for their evaluation or as a means of estimating the total heat input to apparatus utilizing them, as for example, a steam power plant. For either purpose calorimetric work on solid and liquid fuels is usually considered satisfactory if the accuracy is such that duplicate determinations by the same observer agree to within 0.3 of one per cent or if different observers agree to within 0.5 of one per cent on the same sample. The precision obtained with constant-pressure calorimeters used for gases is not so high. Results varying 1.0 per cent from the true value will be considered satisfactory. Accuracy within the limits specified does not require the most precise calorimetric apparatus obtainable, but it does require considerable manipulative skill on the part of the observer. Greater calorimetric accuracy than that mentioned in the foregoing is attainable with refinement of apparatus, but it is generally considered useless to strive for it, particularly in the case of coals where the heating value of the sample may vary one per cent from the true representative value.

3 *Heat Units.* The heat unit used in this branch of calorimetry, the gram calorie, is the heat required to raise the temperature of one gram of water one degree centigrade[10] at 20 deg. cent. The unit commonly used by engineers is the British thermal unit (B.t.u.), which is the heat required to raise the temperature of one pound of water one degree fahrenheit at 68 deg. fahr. To convert results expressed in calories per gram to British thermal units per pound, multiply by the temperature-scale conversion factor 1.8.

4 *Total and Net Heating Values.* To facilitate comparisons between different analysts and laboratories, it is customary to report all determinations on a dry basis. From results obtained in the bomb calorimeter the analyst makes a correction of 13 calories for each per cent of sulphur contained in the fuel and 230 calories per gram of acid formed, both factors being subtractive. These corrections apply when a 1-gram sample is used. The reason for applying them is that no sulphuric acid and little or no nitric acid are formed by the combustion of fuels in air. The result is called the total or determined heating value. Total heat of combustion of solid and liquid fuels, then, will be understood to mean the total heat liberated by combustion in oxygen under high pressure, of a unit mass of the fuel containing carbon and hydrogen with small amounts of oxygen, nitrogen, and sulphur to form carbon dioxide, water, sulphur dioxide, and nitro-

[10] In standard solid and liquid calorimeter practice the centigrade temperature scale is used.

gen, the fuel and oxygen being initially at the same temperature and the products formed being cooled to the initial temperature with water condensed.

5 The net heating value at 20 deg. cent. (68 deg. fahr.) is obtained by correction of the total heating value by latent heat of vaporization of water from the total hydrogen in the fuel. It is equal to: Total heat of combustion in calories—580 (per cent hydrogen × 9) calories per gram, or total heat of combustion in B.t.u.—1040 (per cent hydrogen × 9) B.t.u. per pound.

6 The total heating value of a gas,[11] expressed in the English system of units, is the number of British thermal units produced by the combustion, at constant pressure, of an amount of the gas which would occupy a volume of 1 cubic foot at a temperature of 60 deg. fahr. if saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury at 32 deg. fahr. and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of gas and air, and when the water formed by the combustion is condensed to the liquid phase.

The net heating value of a gas, expressed in the English system of units, is the number of British thermal units produced by combustion, at constant pressure of an amount of the gas which would occupy a volume of 1 cubic foot at a temperature of 60 deg. fahr. if saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury at 32 deg. fahr. and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of gas and air, and the water formed in the combustion remains in the vapor phase.

The observed heating value for a flow calorimeter will be understood to be the value obtained by multiplying the mass of water which flowed through the calorimeter during the test by the corrected rise in temperature of the water, and dividing by the volume (referred to standard conditions of 60 deg. fahr. and 30 inches) of gas burned.

Available Calorimeters

7 Many calorimeters are in use, and accurate determinations of the heats of combustion of solids, liquids, and gases can be made by calorimeters of the following general types:

Berthelot Bomb—for solids, liquids, and gases (see Par. 22).
Constant-Flow—for gases (see Par. 39).

8 Solid and liquid fuels are practically always tested in the Berthelot bomb-type calorimeter, many modifications of which are in use. These modifications arise from differences in mechanical design, convenience of manipulation, etc. There are several different makes available, including the Mahler, Atwater, Emerson, Peters, Richie, Williams, and Parr's Illium Alloy Oxygen Bomb, each having its particular advantages and disadvantages.

9 The essential parts of a bomb calorimeter are:

a The bomb or containers in which the combustible charge is burned.

Bombs made of acid-proof alloys or steel bombs lined with gold or platinum are to be preferred. Monel-metal bombs lined with gold have given good satisfaction, and the same applies to phosphor-bronze gold-plated bombs. Porcelain-lined steel bombs are satisfactory so long as the porcelain remains intact, but this does not last as long as gold or platinum as a rule. Valves and insulated electrodes are usually the first parts of the bomb to fail, and therefore they should be so constructed as to be easily replaceable. Bomb-cap threads are often of such small pitch that they wear out quickly, and a comparatively large pitch is to be preferred.

b The calorimeter proper or vessel containing water in which the bomb and the stirring device for circulating the water around the bomb and the thermometer are immersed.

Turbine stirrers will be found most convenient and very efficient as well; a 2-inch, 3-blade propeller stirrer of 1 inch pitch running at 150 to 200 r.p.m. in a stirrer well will give satisfactory stirring. Smaller propellers running at higher speeds may be used, but in this case the heat input from stirring is apt to be excessive. Heat developed in this way should not exceed 2.5 calories per minute.

c The jacket used to protect the calorimeter from variations in room temperature, air drafts, etc.

Water jackets should also be provided with turbine stirrers.

d Temperature-measuring device.

The instrument used for temperature measurement should be readable by interpolation to 0.001 deg. cent., should have a uniform scale, and should have been calibrated as outlined in Part 3, Chapter 1. Platinum-resistance thermometers are to be preferred from the standpoint of accuracy but mercury-in-glass thermometers, when carefully calibrated, are sufficiently accurate for test purposes.

Range and Accuracy

10 The range of a calorimeter is rather flexible, as the temperature rise can be kept within the prescribed limits by varying the size of the fuel sample used. The temperature rise rarely exceeds 3.5 deg. cent. It is usually between 2 and 3.5 deg. cent. The weight of the sample taken should be as near one gram as possible and still allow the temperature rise to come within the required limits.

11 The accuracy of a calorimetric determination is best judged by duplicate determinations of heat of combustion of Bureau of Standards samples of benzoic acid or naphthalene. These should agree to within 0.3 per cent for the same observer and 0.5 per cent for different observers.

12 By definition, heat units are compound units, involving the product of an intensity factor and a capacity factor. The temperature rise caused by the combustion of a unit weight of fuel multiplied by the heat capacity of the instrument in which the determination is made gives the number of heat units developed. The capacity factor is made up of water plus that capacity contributed by the parts of the instrument known in terms of water. It will be clear, then, that the larger the capacity of the apparatus, the higher the needed precision of the temperature-difference measurement, and vice versa. The capacity of combustion calorimeters will usually vary between 2000 and 3000 grams, and the precision of temperature measurement is rarely better than 0.001 deg. cent. With mercury-in-glass thermometers the calibration usually does not cover the entire bore, unless the bore has been verified by the laborious detached-thread method, hence the absolute accuracy of the temperature-difference estimation may not be closer the truth than 0.003 to 0.005 deg. cent. This would involve an error of, at the most, 15 calories in the final result, which can be tolerated in test-code work. It is possible to attain as high a precision as 0.0001 deg. cent. and a correspondingly high degree of accuracy with the best types of resistance calorimetric thermometers, but this involves the use of complicated apparatus not well adapted to routine test work. On the other hand, it is inadvisable to reduce the calorimeter capacity factor much below 2000 grams for the purpose of lowering the needed precision in temperature measurement, since this involves larger temperature differences, and Newton's cooling law on which the computation of cooling corrections are based applies best to small temperature differences. In the best-designed combustion calorimeters the temperature rise produced by the combustion of one gram of coal will rarely be greater than 3.5 or less than 2.0 deg. cent., as stated in Par. 10.

13 Errors in the application of cooling corrections to com-

[11] "Standard Methods of Gas Testing," Bureau of Standards Circular No. 48, p. 36.

mercial calorimeters have, in the main, two sources: imperfect knowledge of the temperature of the environment (the jacket temperature), and inherent errors in the method of computation. Excessive lag in the calorimeter system may seriously affect the cooling correction. Also, the evaporation and condensation of water in the system during a determination may likewise introduce large errors. The lag effect may easily be made negligible by using a minimum amount of material of low heat conductivity in the parts which contribute to the calorimeter capacity. The evaporation may be controlled by the method of manipulation or by providing an oil seal for the water in the calorimeter. An ideal calorimeter would be one in which the combustion could be performed adiabatically. If this ideal could be realized, practically true heating values would be given by the product of the temperature change and the thermal capacity, and no corrections for heat loss or gain would be necessary. However, it is practically impossible to obtain absolute adiabatic control, and even the nearest approach to this method will be attended by error proportionate to the extent to which the practical conditions depart from this ideal. The precision of control needed depends largely on the normal cooling factor of the instrument and on the time interval covered by the experiment. For example, an instrument having a normal cooling factor of 0.006 deg. cent. per minute per one degree centigrade temperature gradient and 3000 grams capacity, would give errors as large as 10 calories with a 6-minute interval and a deviation from adiabatic control of 0.1 deg. cent. This is shown by an approximate calculation:

$$0.006 \times 0.1 \times 6 \times 3000 = 10.8 \text{ cal.}$$

Adiabatic control accurate to 0.1 per cent is practical, and several instruments in which the adiabatic principle is utilized are now available.

14 An effective method of minimizing cooling-correction errors consists in accurately controlling the temperature of the calorimeter environment. This is done by providing a complete water jacket the temperature of which is kept constant to two or three hundredths of a degree by means of a sensitive thermostat. This method is utilized in the Bureau of Standards calorimeters[12] and also in those used by the Bureau of Mines.[13] This method is capable of a high degree of accuracy and possesses certain advantages as regards facility and certainty of operations, but no commercial instrument of this type is, at present, available.

15 In another instrument, designed for the reduction of the cooling correction, a vacuum jacket is used. This instrument is capable of giving good results, but the foregoing methods are to be preferred where a high degree of accuracy is sought.

INSTALLATION

16 A room of fairly constant temperature is to be preferred where these calorimeters are installed; wherever possible, a small room should be set aside for the purpose, preferably an inside room where temperature can be easily controlled. If it is necessary to install the calorimeter in a large open laboratory, for example, it will be advisable to erect an enclosure to guard against air currents. The best results will be obtained with calorimeters of this type by keeping conditions so adjusted that it is possible to make all determinations cover practically the same temperature range. This should be the range covered in the standardization. Where the temperature of the jacket water may be accurately controlled, the room temperature may be allowed to vary considerably, but here as in the previous case the same temperature range should be covered in all determinations. By taking this precaution one can eliminate the effect of small variations in the temperature scale, and those due to the change in specific heat of the apparatus with temperature as well. Where resistance thermometers are used, care should be taken to protect them from laboratory fumes since even slight corrosion of the electrical contacts is fatal to accuracy. Galvanometers should be mounted in places free from vibration.

17 The calorimeter should be so mounted as always to occupy the same position relative to the jacket. The space between should be uniformly about one-half inch, and the calorimeter supports should consist of the smallest practical contact area of insulating material. In the best designs a number of ivory sticks $^1/_8$ inch in diameter are used; these are fitted into small brass sockets which are soldered to the jacket walls. Contact of any part of the calorimeter with large amounts of insulating material which contributes to the capacity of the instrument is to be avoided since this increases the lag factor. Excessive lag is objectionable since it tends to render the combustion interval indefinite, and thereby affects the accuracy of the cooling correction.

18 There should be a minimum of good conducting material in contact with both jacket and calorimeter. This requires insulating the stirrer shaft and any metallic supports.

19 Most makers of calorimetric apparatus have given facility of operation considerable thought, with the result that equipment very good in this respect is available. The bomb valve and cap seats should be leakproof, and constructed so as to withstand considerable wear. The valve passages should be large (about 0.08 in. bore) to prevent them from becoming clogged. The electrode wires, which usually serve also as a support for the sample, should be of platinum or acid-proof alloy; they should be accessible so as to permit easy attachment of the fuse wire, and heavy enough so that they will not bend easily, otherwise they will break frequently.

20 Where it is necessary to make as many as 50 determinations daily, it will pay to design special equipment using complete water jackets controlled by thermostats. See Figs. 1, 2, and 3.[14] This will permit the elimination of the rate temperature observations otherwise necessary for estimating the cooling correction

[12] Dickinson, H. C., "Combustion Calorimetry and the Heats of Combustion of Cane Sugar, Benzoic Acid, and Naphthalene." Bureau of Standards, Scientific Paper No. 230.

[13] Davis, J. D., and Wallace, E. L., "A Convenient Multiple Unit Calorimeter Installation," Bureau of Mines, Technical Paper 91, 1918.

[14] Not reproduced here.

Leisure

THE purpose of mechanical engineering is to reduce the amount of labor that must be expended upon the production of goods or upon the provision of services. The textile machine, the coal cutter, the machine tool enable men by their use to produce more for a given amount of human energy than without them; the steamship and the locomotive enable them to transport themselves and their products with a much lower total expenditure of energy than was possible before. The prime mover stands behind such inventions; it is the key to all the methods which have been developed for the reduction of human labor. People sometimes wonder why it is that with the marvelous acceleration of production, and the yet existing potentialities, so much human work has still to be done in the world. The answer is, of course, that every improvement has been followed by an increase of demand. If the people of today wanted no more than the people of the seventeenth century, no one would have to labor for more than a very few hours a week. We work long because we want more, and work, either direct or by proxy, must be performed in proportion to the amount of goods or services acquired.—*The Engineer*, September 10, 1930, p. 313.

Proposed Specifications for Fusion Welding of Unfired Pressure Vessels

Based on Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers as Referred to in Par. U-23 Revised

IN A RECENT revision of Par. U-23 of the Code for Unfired Pressure Vessels which is now effective, the following statement is made:

All joints in vessels covered by this Code and of any dimensions may be fusion welded provided that in addition to meeting the requirements for material and design, they will conform to specifications now being prepared for inclusion in this Code, based on those which have been published under the heading, Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers.

In addition to the specifications referred to, certain revisions are proposed to make the rules in Par. U-23 more widely applicable, and it is intended to further extend the scope of the rules covering vessels which may be fusion welded without being stress relieved.

The Committee is considering amplifying the Code so as to make it apply to vessels operated at temperatures of over 600 deg. fahr., and the inclusion of the allowable working stresses for higher temperatures. The Committee is also considering the classification of pressure vessels and should a classification be adopted, these specifications are primarily intended to cover the class of vessels demanding the highest type of construction.

The following proposed revision and specifications for embodiment in the Code for Unfired Pressure Vessels, which are based on those proposed for power boilers published in the March issue of MECHANICAL ENGINEERING, are submitted for criticisms and comments from any one interested. Where additional requirements are given in these Specifications over those for power boilers, they will be considered for inclusion in the Specifications for Drums or shells of Power Boilers. Suggestions on the broadening of the rules covering vessels which need not be stress relieved after welding will also be welcomed by the Boiler Code Committee. Discussion and suggestions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., not later than January 15, 1931, in order that they may be presented to the Committee for consideration.

Par. U-23 Revised

U-23. Pressure vessels may be fabricated by means of fusion welding under the rules given in Pars. U-67 to U-79, provided the fabrication is in accordance with the Recommended Procedure for Fusion Welding of Pressure Vessels given in the Appendix, as follows:

a ALL [Air] vessels OTHER THAN THOSE CONTAINING NOXIOUS LIQUIDS OR GASES when the inside diameter does not exceed 60 in., or the working pressure does not exceed 200 lb. per sq. in., or the temperature does not exceed 250 deg. fahr.

b Vessels, in which the circumferential joints only may be welded, when the inside diameter does not exceed 72 [48] in., or 96 [72] in., when at least 75 per cent of the load on a flat head is supported by tubes or through stays extending from head to head.

All joints in vessels covered by this Code and of any dimensions may be fusion welded provided that in addition to meeting the requirements for material and design, they will conform to the following specifications, based on those which have been published under the heading, Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers.

Proposed Specifications for Fusion Welding of Unfired Pressure Vessels

1 Pressure vessels covered by this Code of any size and for any working pressure may be fabricated by means of fusion welding, provided materials are used which conform with the specifications in Pars. S-5 to S-17, or S-264 to S-279, of Section II of the Code, and the following requirements are fulfilled:

If, in the development of the art of welding, other materials than those herein described become available, specifications may be submitted for consideration.

2 *Test Plates for Longitudinal Joints.* Two sets of test plates of the dimensions shown in Fig. 2 from steel of the same specifications as the drum plates, prepared for welding, shall be attached to the shell being welded, as in Fig. 1, one set on each end of one longitudinal seam of each drum so that the edges to be welded in the test plates are a continuation of and duplication of the corresponding edges of the longitudinal seam in the shell. Weld metal shall be deposited in the test plates continuously with the weld metal deposited in the longitudinal joint of the shell. As an alternate method, detached test plates may be welded as in the case of circumferential seams covered under Par. 3.

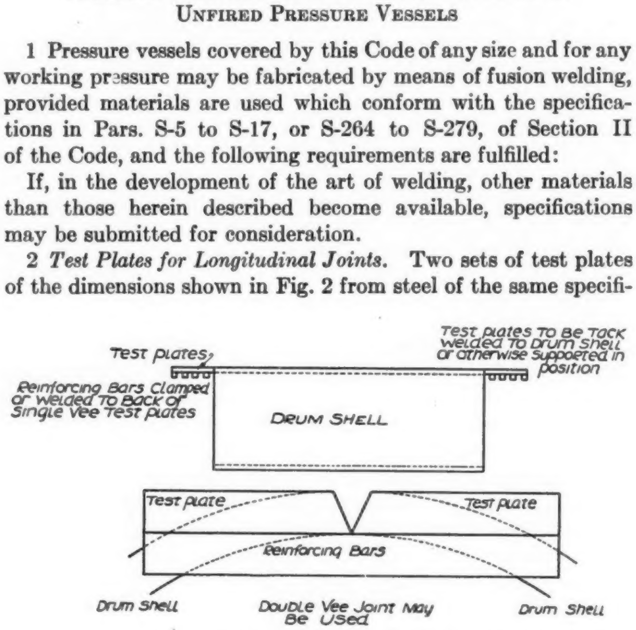


Fig. 1 Longitudinal Test Plates

When the joint is of the single-V type, the test plates shall be so supported that the warping due to welding shall not throw the finished test plate out of line by an angle of over 5 deg.

3 *Test Plates for Circumferential Joints.* When test plates are welded for the longitudinal joints, none need be furnished for circumferential joints in the same vessel provided the welding process, procedure, and technique are the same. Where a drum has circumferential joints and no longitudinal joint, two sets of test plates of the same material as the shell shall be welded in the same way as the circumferential joint.

When the joint is of the single-V type, the test plates shall be so supported that warping due to welding shall not throw the finished test plate out of line by an angle of over 5 deg.

4 *Stress Relieving.* The complete welded structure shall be stress relieved. Stress relieving shall be obtained by heating uniformly to at least 1100 deg. fahr. The structure or parts of the structure shall be brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere. The test plates shall be subjected to the same stress-relieving operation, preferably by placing within the parent vessel.

The structure shall be stress relieved by any of the following methods:

a Heating the complete vessel as a unit.

b Heating a complete section of the vessel (head or course) containing the part or parts to be stress relieved before attachment to other sections of the vessel.

c In cases where the vessel is stress relieved in sections, stress relieving the final girth joints by heating uniformly a circumferential band having a minimum width of 6 times the plate thickness on each side of the welded seam in such a manner that the entire band shall be brought up to the temperature and held for the time specified above for stress relieving.

Where the welding has warped the test plates they shall be straightened cold before being stress relieved.

5 *Test Specimens.* The inspector shall select one of the two welded test plates from which the coupons for tension, impact, and bend tests and for specific-gravity determinations shall be removed as shown in Fig. 2.

6 *Tension Tests.* Two types of tension test specimens are required, one of the joint and the other of the weld metal. The tension specimen of the joint shall be transverse to the welded joint, and shall be the full thickness of the welded plate after the outer and inner surfaces of the weld have been machined to a plane surface flush with the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Each tension specimen should fail in the plate, but if failure occurs in the weld metal or along the line of fusion between weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used.

The tension test specimen of the weld metal shall be taken entirely from the deposited weld metal and shall meet the following requirements for tensile strength, elongation, and reduction of area; tensile strength to be at least that of the minimum of the range of the plate which is welded; elongation and reduction of area to be . . . (values to be agreed upon later). The dimensions of the specimen shall conform to those given in Fig. 3. However, should this not be possible, the diameter shall be made as large as practicable and the gage length used shall be 4 times the diameter of the specimen.

(The minimum value of 20 per cent of elongation and the omission of the reduction of area requirement are being considered.)

7 *Bend Tests.* The bend-test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross-section with the width $1^1/_2$ times the thickness of the plate. When the capacity of the available testing machine does not permit of testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the plate. The edges of this surface shall be rounded to a radius equal to 10 per cent of the thickness of the plate. The specimen shall be bent cold under free bending conditions until the least elongation measured within or across approximately the entire weld on the outside fibers of the bend-test specimen is 30 per cent, with the width of any surface cracks deducted.

8 *Impact Tests.* Three coupons for impact tests shall be taken transverse to the welded joint and prepared so that the cross-section of the specimen through which fracture will occur shall contain: (1) the bottom surface, (2) the middle section, and (3) the top surface of the weld. The notch in the bottom specimen shall be opposite the bottom surface, and in the top

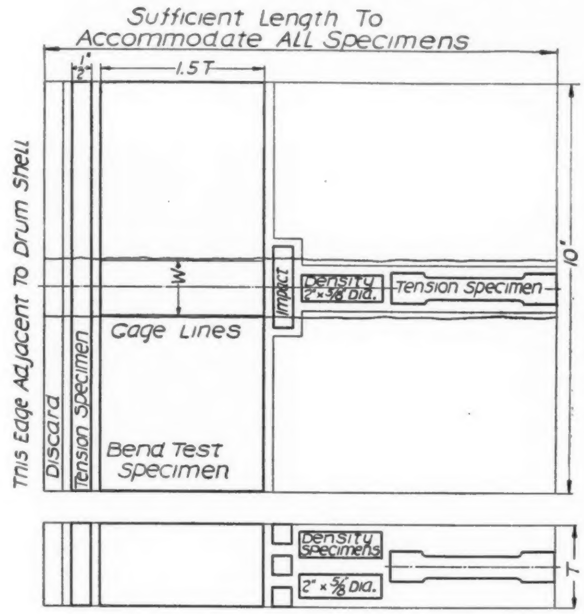


Fig 2
Test Specimens From
Longitudinal Welded Test Plates

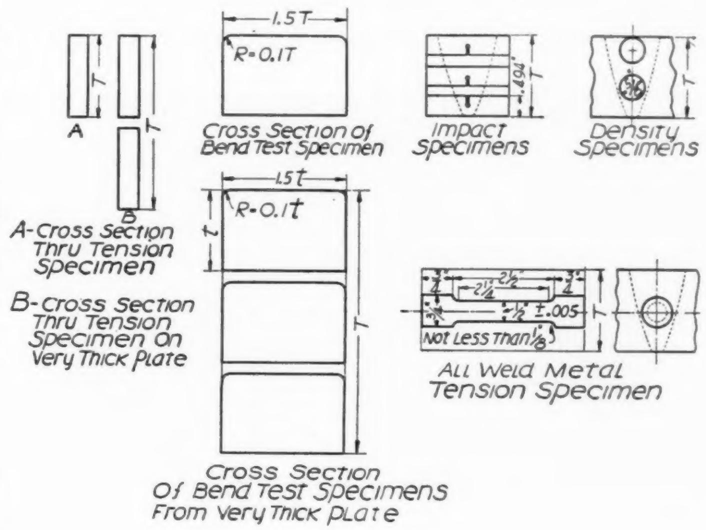
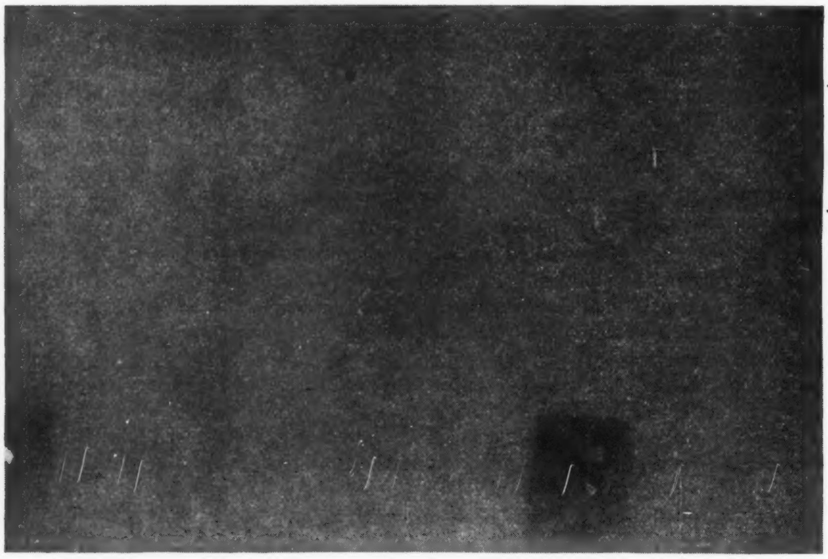


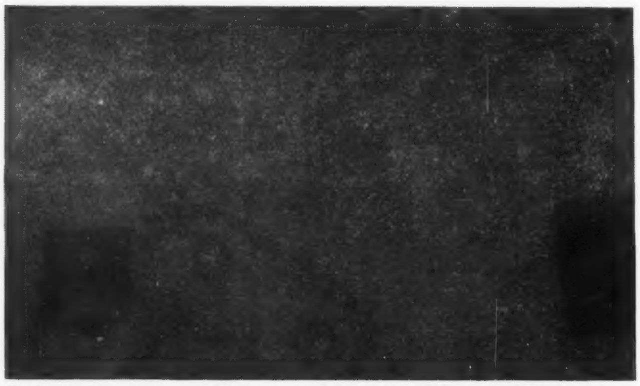
Fig 3
Test Specimens



WELD METAL

MACROGRAPH OF TYPICAL SECTION THROUGH WELD OF TYPE 1

RADIOGRAPH TYPE 1. EXCELLENT OR IDEAL WELD

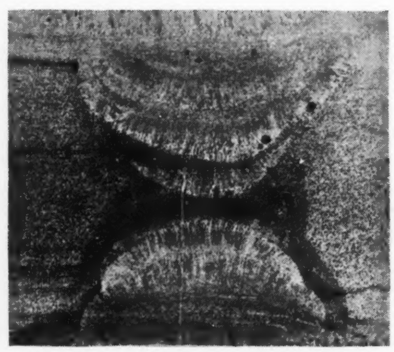


WELD METAL

RADIOGRAPH TYPE 2. POROUS BUT ACCEPTABLE

MACROGRAPH OF TYPICAL SECTION THROUGH WELD OF TYPE 2

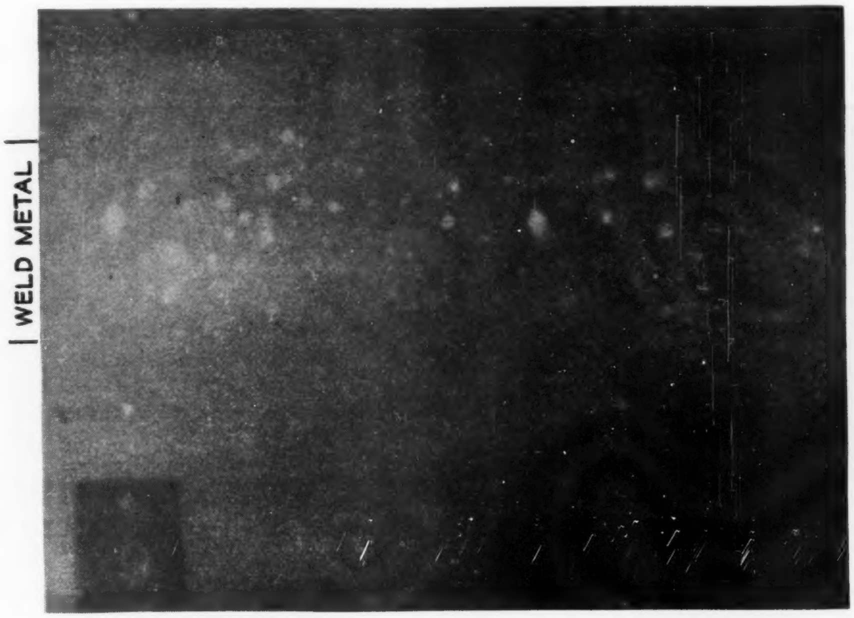
WELD METAL



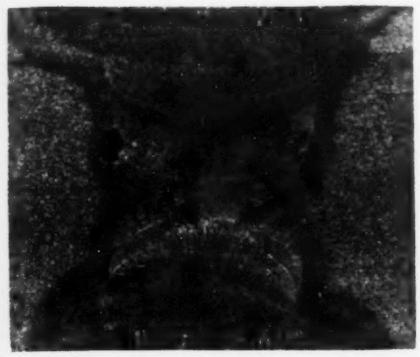
MACROGRAPH OF TYPICAL SECTION THROUGH WELD OF TYPE 2

RADIOGRAPH TYPE 2. POROUS BUT ACCEPTABLE

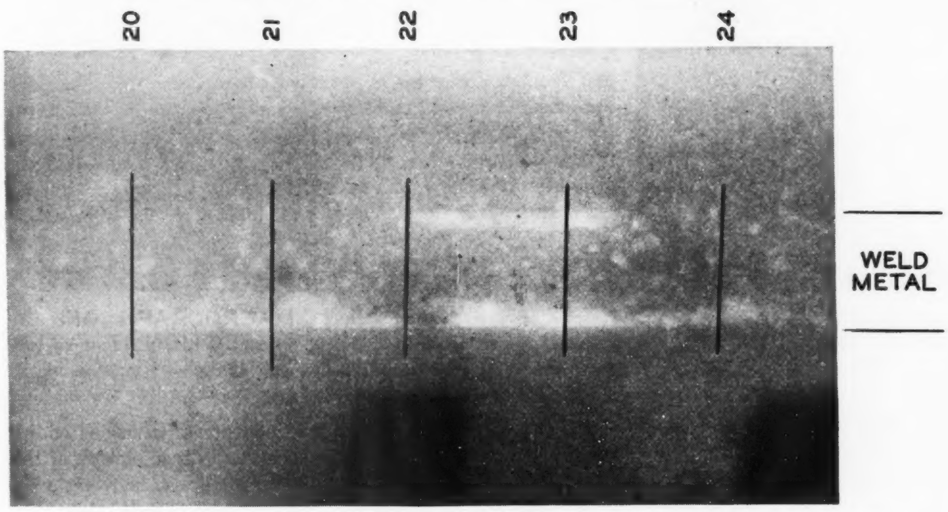
RADIOGRAPHIC PRINTS NOS. 1 AND 2



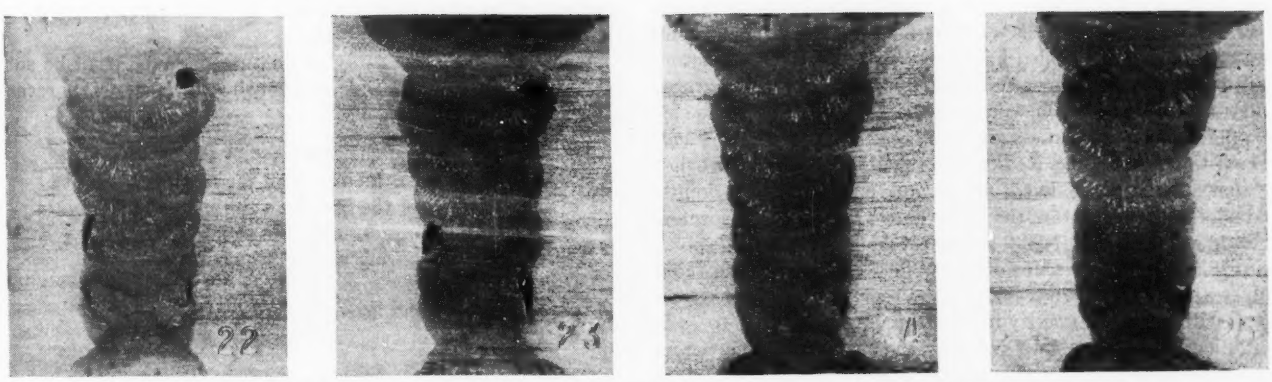
RADIOGRAPH TYPE 3. POROUS AND UNDESIRABLE



MACROGRAPH OF TYPICAL SECTION THROUGH WELD OF TYPE 3



RADIOGRAPH TYPE 4. DEFECT ALONG WALL OF JOINT NOT ACCEPTABLE



MACROGRAPHS OF SECTIONS 21 TO 25 THROUGH WELD IN RADIOGRAPH TYPE 4

RADIOGRAPHIC PRINTS NOS. 3 AND 4

specimen, opposite the top surface. The minimum value of the impact test shall be 20 ft-lb., standard A.S.S.T. Charpy impact specimen, or the equivalent value of 35 ft-lb. in the Izod test.

If the plate is not thick enough to obtain three impact specimens in the same vertical section, the specimens shall be obtained from two or three adjacent sections.

9 *Specific Gravity of Weld Metal.* Specimens shall be taken from the weld metal of the joints. These specimens shall, if possible, be 2 in. long and $^5/_8$ in. in diameter, as shown in Figs. 2 and 3. The minimum specific gravity shall be 7.80.

10 *Retests.* Should any of the tests other than those under Par. 9 fail to meet the requirements by 10 per cent or less, retests shall be allowed on specimens cut from the second welded test plate.

Should any of the tests other than those under Par. 9 fail to meet the requirements by more than 10 per cent, no retests shall be allowed. The retest shall comply with the requirements. For either of the tension retests, two specimens shall be cut from the second test plate and both of these shall meet the requirements.

When there are more than one specimen of the same type and when one or more of the group specimens fail to meet the requirements by 10 per cent or less, the retest shall be made on an entire group of specimens and shall meet the requirements.

Should the specific gravity obtained on the specific-gravity specimen be less than 7.75, no retest shall be allowed. Should the specific gravity lie between 7.75 and 7.80, a retest shall be allowed. The retest shall not show a specific gravity less than 7.80.

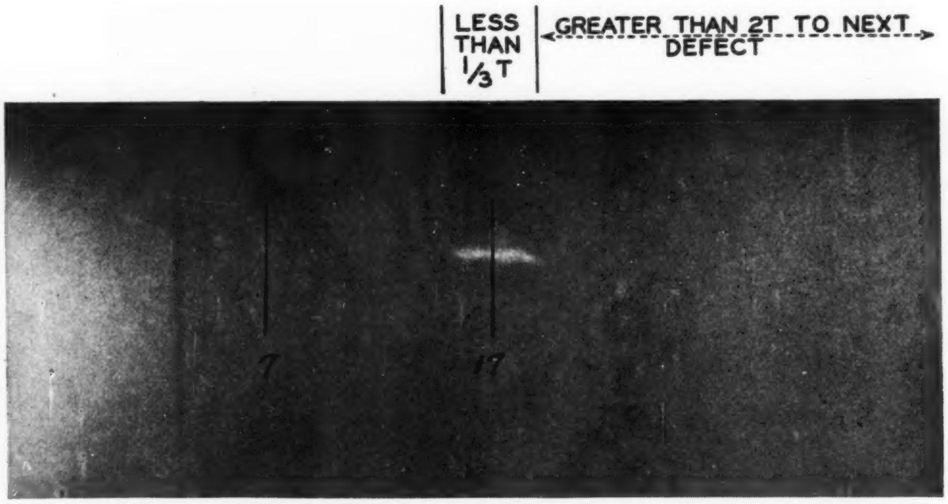
11 *Non-Destructive Tests of Vessel.* The main longitudinal and circumferential welded joints of the stress-relieved structure shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 per cent of the thickness of the base plate. Radiographs shall be obtained for every portion of the main longitudinal and circumferential joints, and photographic prints of the X-ray films submitted to inspector.

Radiographic print No. 1 shows the ideal or desired type of print in which the presence of the welded joint can be detected only with great difficulty. This type represents excellent weld metal with a specific gravity in the neighborhood of 7.80 to 7.85.

Radiographic print No. 2 indicates the presence of some porosity of the weld metal in the joint. This porosity however, is not excessive and radiographs of this type shall be acceptable.

Radiographic print No. 3 represents a porous condition in the weld metal which is not desirable.

Radiographic print No. 4 represents a serious defect in a welded joint. This defect represents a slag inclusion or cavity extending longitudinally along the wall of the joint. A radiograph of this kind is not acceptable. However, a radiograph showing a defect of this kind in which the length of the defect is less than $1/3T$, where T is the thickness of the joint and where these defects are separated from each other by at least $2T$ of solid weld metal, shall be acceptable, provided they shall not average more than 1 per foot for any one seam.



RADIOGRAPH TYPE 5. DEFECT ALONG WALL OF JOINT—ACCEPTABLE

MACROGRAPH OF SECTION 7

MACROGRAPH OF SECTION 17

Radiographic Print No. 5

A description of the X-ray technique employed shall be submitted with the radiographic prints to the inspector, this record giving:

- *a* The thickness of the plate
- *b* The distance of the film from the rear of the joint
- *c* The distance of the film from the source of X-rays
- *d* The voltage impressed on the tube
- *e* The current flowing through the tube
- *f* The time of exposure
- *g* The type of film used
- *h* The type of intensifying screens.

The locations of the reference markers, the images of which appear on the film, shall be accurately and permanently stamped on the outside surface of the vessel near the weld so that a defect appearing on the X-ray print may be accurately located in the actual welded joint.

NOTE: To determine whether the X-ray technique employed is detecting defects of a thickness 2 per cent or greater than the thickness of the base plate, a piece of sheet steel of a thickness equal to 2 per cent of the base plate and containing a hole shall be placed alongside the welded joint so that its image is obtained on the X-ray film but still does not interfere with the image of the welded joint. The image of the hole in the sheet should be obtained on the X-ray film.

12 *Hydrostatic and Hammer Tests.* The vessel shall be subjected to a hydrostatic pressure equal to $1^1/_2$ times the maximum allowable working pressure, and while subject to this hydrostatic pressure a thorough hammer or impact test shall be given. This impact test shall consist of striking the sheet on both sides of the welded seam a sharp blow with a hammer which shall be 10 per cent of the weight of 1 sq. ft. of the wall of the vessel and not less than 2 lb., with a handle similar to a blacksmith's striking hammer, the blows to be struck 2 to 3 in. apart along the seam—the blows to be as rapid as a man can conveniently strike a sharp, swinging blow, and as hard as can be struck without bending the metal of the sheet. During the test the shell shall be completely filled with water. The vessel after the test herein specified shall have the pressure raised to 3 times the maximum allowable working pressure, and held there three minutes.

(Raising the pressure to twice instead of 3 times the maximum allowable working pressure after the hammer test, or to a pressure that will produce a stress of 50 per cent of the minimum tensile strength of the specified range of the base metal is being considered.)

13 *Holes.* No holes shall be located in a welded joint. When holes in the plate are located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

(Omission of this restriction is being considered.)

14 *Allowable Working Stress.* When constructed under the above provisions, the maximum unit working stress of a welded joint at right angles to the direction of the joint may be taken as one-fifth of 80 per cent (16 per cent) of the minimum of the specified tensile range of the plate used.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 602 (Reopened), 660–665, as formulated at the meeting on September 19, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 602 (Reopened)

(Annulled)

CASE No. 660

Inquiry: a Will it be necessary, in the manufacture of thimble-shaped tubes for a porcupine-type boiler construction, which are formed by deep drawing from flat disks with annealing between each draw, to apply the flattening, crushing, or bending tests required in the Specifications for Boiler Tubes, or can they be omitted as provided for sinuous headers in Par. P-9 of the Code? It is to be understood that the material will conform to the chemical requirements for seamless tubes and the finished tubes will be tested to 1000 lb. hydrostatic pressure.

b Inasmuch as such thimble-shaped tubes are secured at one end only and are expanded into holes tapered at least 4 deg. with the axis, will it not be permissible to reduce the amount of projection through the tube sheet below that required by Par. P-252 as follows:

(1) For tubes 1 in. in diameter, at large end not less than $^1/_{16}$ in. or more than $^1/_8$ in.;
(2) For tubes from $1^1/_4$ in. to $1^3/_4$ in., inclusive, not less than $^1/_8$ in. or more than $^1/_4$ in.

It is understood that for tubes of greater diameter than $1^3/_4$ in., the provisions of Par. P-252 will be complied with.

Reply: a It is the opinion of the Committee that each lot of special-shaped thimble tubes shall be subjected to all of the physical tests prescribed in the Specifications for Seamless Boiler Tubes.

b It is the opinion of the Committee that tapered thimble-shaped tubes which are expanded at one end only into tapered holes, may project through the tube sheet from $^1/_{16}$ in. to $^1/_8$ in. when the diameter at the large end does not exceed 1 in., or from $^1/_8$ in. to $^1/_4$ in. when the diameter at the large end is more than 1 in. but does not exceed $1^3/_4$ in., without conflicting with Par. P-252. For such tubes larger than $1^3/_4$ in. at the large end, the provisions of Par. P-252 should be complied with.

CASE No. 661

Inquiry: a Is it permissible to make the cylindrical portion of the furnace of an internally fired boiler of lap-welded pipe which conforms to the Code specifications, or of firebox steel plate with autogenous-welded longitudinal joint? It is to be noted that in order to maintain uniform spacing of tubes, it will be necessary to locate one row of tube holes through or adjacent to the weld.

b Is it permissible to attach the dished head to the cylindrical portion of the furnace by autogenous welding?

c By what method may the strength of the cylindrical furnace, which is in compression, be computed in order to meet the Code requirements? Is it permissible to compute the allowable working pressure by Par. P-240 and decrease this in proportion to the efficiency of the plate along a longitudinal line of holes?

Reply: a The furnace in the boiler referred to may, in accordance with Par. P-9 of the Code, be formed of lap-welded pipe, or if it is cylindrical so that no cross-strains tending to induce tension stress develop in the longitudinal joint, it is the opinion of the Committee that welding will not conflict with the requirements of Par. P-186.

b The Code does not prohibit this method of construction.

c The Committee approves the method outlined for comput-

ing the maximum allowable working pressure by using Par. P-240 of the Code which applies to a furnace having no holes in the shell and decreasing the allowable working pressure so determined by multiplying it by the efficiency of the plate in a longitudinal direction through a line of tube holes. The Committee suggests, however, that after fabrication, one of the boilers be tested under hydrostatic pressure to destruction to determine the maximum allowable working pressure.

CASE No. 662

Inquiry: Is it necessary, under the requirements of Par. P-186, where flanged edges of a fire-door opening are welded and the surrounding row of staybolts is spaced one full pitch therefrom, that the staybolts be proportioned to carry the pressure based on the full pitch plus the half pitch out to the edge of the welded flange?

Reply: When both the outside and furnace sheets are flanged-in for the fire-door opening and welded as specified in Par. P-186, it is the opinion of the Committee that the plates are amply reinforced thereby, so that the staybolts surrounding the door opening may be calculated for only that pressure which comes on the normal pitch area.

CASE No. 663

(In the hands of the Committee)

CASE No. 664

(In the hands of the Committee)

CASE No. 665

Inquiry: Is it the intent of the Committee that automatic welding may be used for fabricating welded tanks? The requirements in the Code for the qualifications for welders indicate that machine welders cannot be used.

Reply: The preface or introductory statement in the Recommended Procedure in the Appendix states that its subject-matter is general in character and contemplates the use of either hand or machine welding. It is the opinion of the Committee that if a machine-welding process is subjected to the qualification test and meets the requirements prescribed in Chapter IV of the Procedure, the process in question will be acceptable for welding under the Rules of the Code for Unfired Pressure Vessels, as the skill required in adjusting and manipulating a welding machine is equivalent to that required in manual welding.

Errata

The following corrections of the A.S.M.E. Boiler Construction Code are to be noted on the pink-colored addenda pages approved on August 12, 1930, and recently distributed:

PAR. P-193*b*. In the second formula, E in the formula should be K.

PARS. P-268*e* AND U-59*e*. In the fourth line of P-268*e*, replace the word "manholes" by the word "nozzles," and in the fifth line omit the words "P-260 and." In the fourth line of Par. U-59*e* replace the word "manholes" by the word "nozzles," and in the fifth line omit the words "U-55, U-56 and."

PARS. P-268*j* AND U-77. Omit the sentence "If K is less than 0.33, the maximum allowable value of d shall be $0.231D$" where it appears after the second formula in these paragraphs.

PAR. U-59*a*. In the second line of the fifth section of this paragraph, replace the figure "100" by "125."

Par. U-68. Add the following:
"Spot or intermittent girth or head welds . . . . . . 5600 lb.
For butt single-V longitudinal welds and for material of thickness of less than $^1/_4$ in., the maximum allowable working stress shall not exceed 5600 lb. per sq. in."

Correspondence

Broadening Effects of Engineering Education Demonstrated by Statistics

TO THE EDITOR:

A year ago an important article in MECHANICAL ENGINEERING presented in convincing statistical manner the broad activities of engineers and manufacturers whose names were recorded in "Who's Who in America." There was ample refutation of the frequently expressed, but obviously unjust, charge that the engineer is narrow, and both unwilling and unqualified to participate in the political and cultural life of his community. Evidence is now available to show that this catholic interest of the engineer does not develop in later years, but is part of his equipment when he leaves college. We have been led to believe that the arts curriculum of our colleges gives breadth of view and variety of interest. The engineering courses, we have been told, are too utilitarian, and the engineering student suffers from overspecialization. We have received recently definite proof that this is not true.

At the invitation of the Association of College Presidents of Pennsylvania and the Department of Public Instruction of the Commonwealth, the Carnegie Foundation for the Advancement of Teaching is making a most elaborate study of secondary and collegiate education in this state. Dr. W. S. Learned is general director of the program, and Dr. Ben Wood, of Columbia, has supervised the construction of the examinations.

An important part of the study was a comprehensive examination in all fields of knowledge to measure the content of the students' minds. This test of approximately 3500 questions, requiring twelve hours, was taken by all the seniors in 49 colleges, universities, and normal schools in Pennsylvania. There has just been made available an analysis of the results of this examination on the basis of a division into groups according to the major subject of study. There were several small groups majoring in subjects such as zoology, German, sociology, etc., but only nine groups comprising more than one hundred students each, thus making their averages of statistical importance. In the order of size these groups are: English, 964; Economics, 944; Engineering, 467; Chemistry, 418; Education, 278; History, 257; French, 148; Mathematics, 122; Household Arts, 101.

The examination questions were divided into three major fields: literature and fine arts, social science, and natural science. It would be expected that engineers and chemists would rank high in natural science, but because of the large amount of time devoted to the engineering subjects in a technical curriculum, low scores in literature and social science would be in order.

However, the ranking of these nine groups by total scores was as follows:

1 Chemistry	4 English	7 Economics
2 Engineering	5 History	8 Education
3 Mathematics	6 French	9 Household Arts

The relative average concentration of study in the major fields is given by the following table:

		Credit hours
1	Engineering	78
2	Economics	59
3	Household Arts	47
4	Chemistry	33
5	English	31

		Credit hours
6	Education	29
7	Mathematics	27
8	French	26
9	History	26

In spite of the fact that more than half the college course for the engineers was devoted to professional subjects and many more hours to the fundamental sciences, the seniors possessed a breadth of knowledge sufficient to score much higher in fields not their own than the arts men were able to do. And if this remarkable record is due in part to superior native ability, we may still be quite as proud of the next generation of engineers.

DONALD B. PRENTICE.[1]

Easton, Pa.

Ira Nelson Hollis at Harvard University

TO THE EDITOR:

The selection of Ira Nelson Hollis as professor of mechanical engineering at the Lawrence Scientific School of Harvard University in 1893 was a stroke of good fortune both for the Lawrence Scientific School and for the university as a whole. His appointment might well have been looked on with grave misgivings. This man, to whom the development of the instruction in engineering was entrusted, had been in the United States Navy for the preceding nineteen years. and his whole adult experience had been in an institution in which strict discipline was universal and in which no order was ever questioned. He had now to control an institution in which individualism was both traditional and encouraged. He fitted into this environment as if he had never known any other. His strength and individuality were such that he was affected but slightly by environment; fundamentally he remained almost untouched. As the navy experience had left him without the military point of view, so also his twenty years at Harvard did not succeed in making him academic.

As a teacher Hollis was unusually well equipped, combining a thorough grounding in the basic engineering sciences with a varied and extensive practical experience. His accessibility and ready sympathy created a bond with his students which quickly transmuted itself into affection. The shirking student received from Hollis (in private) a castigation which for outspokenness was quite unusual in academic circles; the earnest student found nothing but helpfulness. His classes were always animated: an endless fund of apposite anecdote and of illuminating experience vivified his development of theorems in applied mechanics and similar abstruse subjects.

As an administrator Hollis commanded and justified the confidence of his colleagues. His loyalty to them and his constant endeavor to supply their needs were never in question. He found a school of good quality, but small and inadequately manned; when he gave up his direction, it was second to none in its standards and in the ability of its teaching staff.

Hollis had a maturity and wisdom that soon caused his advice to be sought in many departments of the university, and, in a very short time, he became a leader in numerous nonacademic activities. As chairman of the athletic committee, he undertook the considerable task of converting the marsh lands (which had been presented to the university for that purpose) into the playing field now known as Soldiers Field; draining, grading, and erecting athletic buildings, including that colossal structure, the stadium. His courage in building that structure of reinforced concrete, in the face of the grave doubts then existing as to the durability of such a structure in a New England climate, and his willingness to assume full responsibility, were characteristic of the man. As chairman of the athletic committee he advocated and, for the first time, succeeded in putting through a series of regulations for intercollegiate contests which practically removed the atmosphere of suspicion that had previously prevailed, and which went far toward eliminating all taint of professionalism in the form of subsidized athletes. A further important service for the university was his connection with the Harvard Union, both in the construction of the building and, even more important, in its operation through its first years. These and other services were undertaken, according to Hollis, as an indirect means for enhancing, within the university, the reputation of the engineering school. As a matter of fact, this was not strictly so. Hollis was a great organizer and leader, and had a high ideal of service to the community in which he lived. It is inevitable that the possessor of those qualities should exercise them whenever an appealing occasion is presented. He threw himself with great ardor into any task he had assumed, and always with singular sanity of judgment.

The election of Hollis to the board of overseers—an honor usually obtained only by distinguished graduates of the university—gave striking evidence of the confidence and respect with which he was regarded by the vast body of Harvard alumni.

The success of Hollis was helped by his unusual personal popularity. His geniality and capacity for comradeship, which enlivened every company in which he was present, soon brought him many friends who relied on his judgment and were anxious to back him up in the projects in which he was interested. Even the frigidity of the Back Bay of Boston was appreciably tempered by his presence.

There was a striking duality in the nature of Hollis. Notwithstanding his exceptional social gifts, he was essentially a solitary man. Those who met him only in the company of others had no indication of the brooding and sensitive personality beneath. Those with whom he was intimate knew him as one who always gave, but seldom received.

LIONEL S. MARKS.[2]

Cambridge, Mass.

Design of Steam Piping to Care for Expansion

TO THE EDITOR:

The undersigned members of the Syracuse Section have had occasion in the course of their work to make use of paper No. FSP-51-52, by W. H. Shipman, entitled "Design of Steam Piping to Care for Expansion," published in the 1929 Transactions of the A.S.M.E.

On page 418 of this paper appears a table of the evaluations of a group of line integrals. These integrals have been carefully checked and three errors have been noted:

The C-integral for the slant line, given as

$$s\left(\frac{s^2}{3} + x_1x_2\right)$$

should instead be

$$s\left[\frac{x_2 - x_1^2}{3} + x_1x_2\right]$$

The G-integral for the slant line, given as

$$s\left(\frac{s^2}{3} + y_1y_2\right)$$

[1] Dean and Professor of Mechanical Engineering, Lafayette College. Mem. A.S.M.E.

[2] Professor of Mechanical Engineering, Harvard University. Mem. A.S.M.E.

should instead be:

$$s\left[\frac{y_2 - y_1^2}{3} + y_2y_1\right]$$

The *B*-integral for the indeterminate arc of a circle, given as

$$Ay\left[x\ (\cos\theta_2 - \cos\theta_1) + \frac{R}{2}\left(\sin^2\theta_2 - \sin^2\theta_1\right)\right]KR^2$$

should instead be:

$$AY - \left[x(\cos\theta_2 - \cos\theta_1) + \frac{R}{2}\left(\sin^2\theta_2 - \sin^2\theta_1\right)\right]KR^2$$

We are reasonably sure that these are the only errors in the table.

Z. G. Deutsch,[3]
A. M. Larsen,[4]
H. F. Young.[5]

Syracuse, N. Y.

To the Editor:

I have received and examined the corrections to my paper on "Design of Steam Piping to Care for Expansion," which have been suggested by Messrs. Deutsch, Larsen, and Young, of Syracuse. Inasmuch as all of my basic material and my own copy of the final paper were left with the Atmospheric Nitrogen Corporation, I referred the matter to my former collaborators. They have just replied as follows:

"The changes proposed by the Syracuse men are correct. We find on our original copy the same corrections of the slant-line constants; the omission of the minus sign in the curve constant is typographical.

"Personally we use the slant-line constants in the following form:

$$C = \frac{s}{3}\left(x_2^2 + x_1x_2 + x_1^2\right)$$

$$G = \frac{s}{3}\left(y_2^2 + y_1y_2 + y_1^2\right)$$

but the form proposed by these men is equally correct."

W. H. Shipman.[6]

New York, N. Y.

Crankless Reciprocating Machines

To the Editor:

Mr. Michell's paper on the above subject[7] is of particular interest to the writer because he has long been interested in this general type of mechanism and agrees with the author that it offers distinct advantages for many applications of prime movers, pumps, and compressors.

The author is in error in making the general statement that the motion of the pistons in the forms shown in his Figs. 3 and 4 is not truly harmonic. If the radius of the wabble-plate ball centers lies in the same plane as the intersection of the wabble-plate and shaft center lines, and if the radius of said ball centers be such that their path is the same distance outside of the cylinder axis at midstroke as it is inside of the cylinder axis at both end strokes, and if the wabble plate is so restrained that its nutation is of uniform angular velocity, the pistons will reciprocate with a true harmonic motion. In that case the said ball centers will describe a truly circular path at a uniform angular velocity around the cylinder axis, as viewed endwise, making one complete revolution during each stroke. The center lines of the connecting rods, if such are used, then describe a conical path about the cylinder axis and make a constant angle therewith. These facts may be proved by geometrical construction or calculation.

The double-gymbal wabble-plate restraint of Fig. 3 does not provide a uniform nutation of the wabble plate, so that the piston motion in this case is somewhat irregular. The restraining method shown in Fig. 4 comes closer to perfection in this respect, the action being perfect in the case of an infinite number of cylinders. The preferred form of restraint consists of a bevel gear fixed on the wabble plate and rolling in mesh with a duplicate gear carried on the cylinder assembly. This method assures perfect nutation and also removes the reaction-torque load from the pistons.

Referring to the author's special form, it is rather surprising that he should feel impelled to coin a new word to describe what has long been known as a "swash plate." The dictionary defines the term as meaning a flat plate fixed to a shaft at an angle and rotating therewith. There is some reason to doubt that the swash-plate mechanism with slipper shoes will show a very high efficiency under commercial conditions. The assured supply of an adequate quantity of oil to the shoes offers some difficulties, so that the stated coefficient may be realizable only under laboratory conditions. Moreover the slipper bearings are at a considerable radius from the shaft center and their surface speed is high, which means a high shearing resistance of the oil film and a correspondingly high friction torque. Actual test data from an engine of this type would be of much interest in this connection.

Some time ago Mr. Michell published a demonstration of the perfect balance which is possible with his engine when the piston weights are properly related to the unbalance moment created by the swash plate. The same perfect balance can also be obtained in the opposed-piston double-wabble-plate engine, which is the form in which the writer has been chiefly interested.

The latter form is particularly well adapted to two-stroke-Diesel-engine requirements and offers light weight and compactness advantages of great importance, especially valuable for aircraft and locomotive propulsion. Since all high-velocity bearings except the pistons can be ball or roller, and all low-velocity bearings are either rolling-cone or easily lubricated surface bearings, the mechanical efficiency is high. Such an engine can be operated with its shaft either horizontal or vertical, and the inherent accessability is quite unusual.

The following figures from actual designs will illustrate the possibilities of the wabble-plate engine. An aircraft engine of 1500 hp. has the small overall diameter (width and height) of 42 in. and length of 90 in. with reduction gear, the weight being about 2.5 lb. per hp. A vertical-shaft 4000-hp. unit for Diesel electric locomotive application has a diameter of 60 in. and overall height of 98 in. The accessibility is in the latter case almost ideal.

The development of conventional crank and connecting-rod engines has nearly reached its peak in these attributes, and we must turn to unconventional forms of engine mechanisms for applications demanding material further reduction of bulk and weight. The writer is convinced that the wabble-plate mechanism offers the greatest possibilities in this direction.

Leigh M. Griffith.[8]

Los Angeles, Calif.

[3] Solvay Process Co., Syracuse, N. Y. Jun. A.S.M.E.

[4] Assistant Design Engineer, Solvay, Process Co., Solvay, N.Y. Assoc-Mem. A.S.M.E.

[5] Engineering Division, Solvay, Process Co., Solvay, N. Y. Assoc-Mem. A.S.M.E.

[6] Manager of Research, *Product Engineering.*

[7] "Crankless Reciprocating Machines," by A. G. M. Michell. Trans. A.S.M.E., vol. 52, no. 15, May-August, 1930, paper APM-52-7.

[8] Mechanical Engineer. Mem. A.S.M.E.

Engineering and Industrial Standardization

Code for Pulverized-Fuel Systems Approved

THE "Safety Code for the Installation of Pulverized Fuel-Systems" (Z12a–1930) was approved by the American Standards Association on September 4, 1930.

This code is a revision of the code approved in 1927 and was made necessary through the rapid increase in the use of pulverized fuel which has brought into being new developments in methods and equipment. The code covers the construction of buildings housing fuel-pulverizing equipment, the ventilation of these buildings, and specifications for dust-collection systems. Specifications are given covering methods of preventing explosions through static, through the drying of coal, and through its transportation through pipe lines. The code also contains suggestions for safe operating rules to be printed on instruction cards which can be used for guidance by the employees who are in charge of the operation of such systems.

The standard is one of a group covering the general dust-explosion hazards. Other codes in this group which have been approved include "Pulverizing Systems for Sugar and Cocoa" (Z12b–1930); "Prevention of Dust Explosions in Starch Factories" (Z12c–1927), in Flour and Feed Mills (Z12d–1928), and in Terminal Grain Elevators (Z12e–1928).

The National Fire Protection Association and the United States Department of Agriculture are sponsors for the project (Z12) "Safety Codes for the Prevention of Dust Explosions" which includes the codes listed above.

Copies of the code are available at five cents each from the American Standards Association, 29 West 39th Street, New York City.

Fire Fighting in Metal Mines

A DISAGREEABLE odor, shot through ventilation lines at the rate of thousands of feet per minute, will be used to warn miners of fire in all metal mines complying with the provisions of the American Standard code for fire fighting in metal mines. The standard has just been approved by the American Standards Association following its submittal by the National Fire Protection Association and the American Mining Congress, sponsors for the joint technical committee which has been working on the standard under American Standards Association auspices since early in 1925.

Provision is made in the standard for measures to be taken for the prevention of fires, fire-fighting equipment, fire-fighting personnel, and warnings of fires.

In addition to the use of a disagreeable odor as a warning signal, the standard also provides that in mines equipped with electric lights the engineers shall also flash all electric lights nine times in three series of three flashes each. Since trouble may develop in the electrical system, however, the odor signal is considered to be the more reliable warning.

The Low-Voltage Hazard

CONTACT with the so-called "low-voltage" electric current, carrying charges of from 110 to 750 volts, is always dangerous and, under certain conditions, fatal. There have been more than 100 such cases which have resulted fatally in the United States and Canada during the past two years. This is a small number of course compared with accidental deaths in other fields, yet it brings out the fact that the dangers of low voltage are quite generally underestimated.

For the past year a special committee of the American Society of Safety Engineers—Engineering Section, National Safety Council—has been studying low-voltage hazards and the peculiar circumstances surrounding the cases which have come to its attention. The progress report which has just recently been completed reveals some interesting facts: Forty-four or more than two-fifths of 107 cases studied were caused by the ordinary 110 alternating-current voltage.

There were 58 pure industrial fatalities in the group, nine mine fatalities, and four railroad tragedies. Home fatalities rank second to industry with 31 deaths. Bathtub fatalities led the domestic list with 12 deaths. Next in importance came fatalities from contact while on wet basements or earth, with seven fatalities. Portable appliances came next in the home with six tragedies, and amateur experiments caused one fatality.

The report shows that at least one-third of the fatalities may be attributed to defective materials such as the lamp cord not properly maintained. Five to twelve per cent are due to installations not in accordance with standard practices as represented by the National Electric Code. Ten to fifteen per cent are due to handling live parts, and about 8 per cent more to improper practices, from which are excluded the ignorant handling of radio aerials and a few disastrous amateur experiments.

The report emphasizes the necessity of using proper types of extension cords and the careful maintenance of such cords and all other electrical equipment. The use of weatherproof sockets is urged, as is also the proper grounding of portable devices of all kinds when used in damp locations. The report discourages the use of portable appliances in the bathroom, and urges the practice of "killing" circuits at all times before attempting to work on them.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of October 15–November 15, 1930:

Methods of Routine Analysis of White Pigments, K15. (American Standard.)

Method of Laboratory Sampling and Analysis of Coal and Coke, (Revision of K18-1929). (American Standard.)

Sponsored by the American Society for Testing Materials. Published by the A.S.T.M.

Fire-Fighting Equipment in Metal Mines, M17. (American Recommended Practice.)

Sponsored by the American Mining Congress and the National Fire Protection Association. Published by the A.M.C.

Safety Code for Mechanical Refrigeration, B9. (American Standard.)

Sponsored by the American Society of Refrigerating Engineers. Published by the A.S.R.E.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

Retrogression

A CITY in the Middle West has decided that its emergency employment on public works shall be done without machine aid—picks and shovels for the men to give more jobs. A group of workers in the leather trade has decided to restrict the use of machinery in making pocketbooks—more workers can be employed. But what about the cost of public works and pocketbooks?

These are signs of the times—typical of what has been the attitude of certain persons ever since the introduction of machinery. Advancement comes en masse, but starvation by individuals. It is of little satisfaction to the man out of work that society, as a whole, is less miserable than it was a century ago. And these palliatives that seek a return to the good old days when "man worked from sun to sun," and "Adam delved and Eve span"—days that antedated "technological unemployment"—are signs of retrogression. If because of a few casualties we retreat, we lose ground in our conquest of human misery, and either lay ourselves open to defeat or postpone the ultimate victory. Better a few field hospitals and an advance with courage and determination than a retreat. We need some economic generals and social strategists.

Short-Period Guarantee of Employment

IN THIS time of heavy unemployment a very undesirable situation is created by the fact that even those men who have jobs are uncertain as to how long they will continue to stay on the payroll. This begets a feeling of uncertainty, worry, which not only affects the output of the men but causes them to resort to extreme economies, and these in turn materially reduce the normal volume of purchases by the men and thus accentuate bad times.

Actually this situation is entirely unnecessary today. The boom times of 1929 have been pretty well liquidated by now, and while further cuts in employment in certain lines of business are still not impossible, plants will have to run even if they work as the steel mills do today at only 50 to 60 per cent of their capacity. Even if conditions of business become such as to require still further cuts in man power, which, by the way, is not very likely, probably not more than 10 per cent of the men now employed will be affected, while the other 90 per cent will no doubt keep their jobs throughout.

It would be comparatively simple under these conditions for employers to create a spirit of confidence, raise the morale of their organizations, and incidentally promote the buying campaigns now under way throughout the country by the simple expedient of guaranteeing employment to men now on the payroll for a period of from four to six weeks only, explaining very carefully that this does not mean that dismissals are contemplated after that time, but that it is merely a reasonable precaution against unforeseen events. The general feeling is that the present period of depression is a temporary one and that better times may be expected with the turn of the year, with possibly normal conditions by spring. A guarantee of employment for four to six weeks would therefore mean that those affected would be certain of keeping their jobs during what appears to be the worst period, and would probably materially improve the situation generally, particularly in the smaller towns where the mill wages are the life blood of the local concerns. It would probably be taken on the whole as a mark of confidence in the return of good times on the part of employers of labor. Incidentally, in times to come there is no doubt that labor would remember that when the winter was cold and jobs were scarce, employers came forward with a scheme for its protection.

From every point of view this scheme would appear to be a profitable one all around, and one that does not involve more than a practically negligible risk to the employers.

A Look at the Coal Industry

WHETHER or not the coal industry takes to heart the thoughtful suggestions contained in the paper which Harold V. Coes read at the meeting of the A.I.M.E. Coal Division at Pittsburgh, Pa., in September, will depend upon its leaders, actual or potential. For some years the industry has been in an unhealthy condition, the result of a cyclic depression to which most industries are sooner or later exposed and from which recovery comes by drastic and almost superhuman efforts of a decidedly radical nature. Without stressing too severely the accusation that the difficulties in which the industry has wallowed for some time are probably self-inflicted, it may be suggested once more that other industries have brought themselves out of similar doldrums, and still others have responded to the tonic of change and competition with extraordinarily successful results.

Mr. Coes's address, published in the November issue of *Mining and Metallurgy*, is entitled "Solving Distribution Problems by Merger," and after discussing certain aspects of mergers, turns to the coal industry.

"In so far as I am aware," says Mr. Coes, "most of the important developments in fuel-burning efficiency .... have come from without the industry. Yet it is quite conceivable that co-operative research between the producers of coal, the producers of fuel-burning equipment, and the fuel users would bring about developments of major importance. The invasion of the coal

market by competing commodities such as fuel oil, natural gas, coke, and artificial fuels requires, it seems to me, very intelligent consideration, on the part of the coal producers and distributors, of sound plans to meet the situations thereby presented. The vast bulk of the coal used is most inefficiently consumed."

Mr. Coes then makes some specific suggestions for merchandising plans and coal preparation, and answers in advance some natural objections to his proposals. "The strength of my position lies," he concludes, "in the fact that I am not a coal operator. I do not know that it cannot be done. On the other hand, it is further strengthened by the fact that I have seen other industries solve similar problems by similar means."

There is much merit in the admonition to make stepping stones out of stumbling blocks; and many homely virtues are necessary for such accomplishment. But besides faith and courage and hard work, imagination and intelligent and scientific methods of attacking the problem are essential. If today agriculture, textiles, and coal suffer for not having kept abreast of the times, tomorrow it may be the railroads and the public utilities. It is easy to have confidence in the perpetuation of prosperity; hard to recognize the seriousness of the menaces of competition and technological progress. The man who makes buggies cannot help it if the automobile takes his business away, but he has only himself to blame if he becomes a bankrupt instead of a successful automobile manufacturer. In the meantime no one producing or distributing coal should miss the opportunity of reading Mr. Coes's address.

Naval-Armament Tests

SEVERAL vessels are going to be scrapped by the United States Navy partly as a result of normal obsolescence and partly in compliance with the provisions of the London pact for the reduction of naval armaments. Might it not be a good idea to use these vessels in a repetition of the aircraft bombing tests made seven or eight years ago off the Virginia capes?

At that time the aircraft possessed by the United States Army, which did the bombing, were very crude and of types entirely unsuitable for the purpose in hand. The Navy likewise was not prepared to utilize properly the results obtained, because of lack of previous experience with this kind of work. Today the situation is entirely different. The United States military and naval authorities are in possession of powerful modern craft of various types and sizes eminently capable of taking part in an experiment of that kind. In the intervening years the Navy has studied the question of air operation with and against surface vessels, and has collected a large amount of information which is already being incorporated in the design and construction of naval craft. Telemechanisms have been developed to a high degree of efficiency both for aircraft and for general purposes, and today surface vessels can be operated from a distance either by wireless control or by a combination of wireless control and perforated-strip mechanism, with an efficiency practically equal to that of crew-operated vessels. Ship protection against aircraft by anti-aircraft artillery has also made enormous progress, and it would be intensely interesting to see whether under all of these conditions aircraft could blow ships out of the water, and exactly what damage air attack by demolition bombs could do to actual vessels. It would also be of interest to try out the effect of phosphorus bombs and of laying gas-filled smoke screens. It is quite generally known that all of these problems have received the most serious consideration on the part of our naval authorities, but a real test on a full-sized vessel, as far as we know, has never been made, and those who have faith in the development of aircraft are inclined to believe their effectiveness in an actual test would prove to be more startling than would be generally expected or admitted. The amount of money that the Navy Department can recover by junking these vessels is going to be a very insignificant one at best, while the results of some such tests as those outlined above might have a tremendous value if only in showing to the man in the street that with the best desires to live in peace with its neighbors, this country cannot afford to remain without proper military protection.

Research in Dull Times

WHEN times are flush, industrial organizations are naturally inclined to be liberal with their expenditures. This applies to membership in the various trade organizations, advertising expenditures, social work, and, incidentally, research. When times become dull it is these activities which are curtailed first of all, with some exceptions. However, there are companies which, as far as research is concerned, take a somewhat different attitude, namely, that the time to carry on research is when business is slow and when the research men can devote their whole time to the main problem without being called away from it to supervise production and solve minor troubles occurring in the shops. There is much to be said for this view. The time to install fire-protection devices is not when the conflagration has already started. It takes time to translate the work of the research laboratories into commercial activities, and this work should be done in dull times so that when business becomes active the plant will have the benefit of new processes and new methods.

After all, a sane view of research is that it is merely the preparation of new methods of manufacture and the development of new products to be placed on the market when it is ready to take them. If a plant is making bronze bearings and the research department is working on a new composition, time must be given to the research men not only to develop this composition but to try it out properly and then devise, if necessary, methods for its production, which may mean such things as control of the temperature of pouring, heat treatment, etc. This may call for a period of cooperation between the research department and the production departments, which again takes time, and incidentally can be done much better when the latter are not rushed. From every point of view it would therefore appear to be reasonable to concentrate on research activities particularly during periods of depression.

That the other policy, that is, the drastic curtailment of research activities during dull times, is a very short-sighted one, was dramatically illustrated during the panic of 1907 in the case of the Westinghouse Electric and Manufacturing Company, which was one of the companies that then got into trouble. Mr. George Westinghouse was rather ungently removed from control, and the bankers who took over the company dismissed practically the entire research staff. Shortly afterward business revived, but it was many years before the Westinghouse Company was able to get back its share of business, and this not until, at much trouble and expense, its research and engineering departments had been rebuilt and brought to their previous state of excellence. This happened nearly a generation ago, and no trace of the upset of those days can be discovered in the company as it is today. But the lesson remains just as clear now as it was twenty-three years ago.

It is not generally realized that if even the very largest companies, worth from one-half billion to four billions and upward, were to be deprived of the results of research carried out within the last ten years, they would have to be sold out by the sheriff in short order. What would have happened, for example, to the Standard Oil Company of New Jersey if it had been deprived of the right to use the cracking process in the manufacture of gasoline? With all of its millions of assets it would simply have

had to go out of business, and the same thing would happen to the magnificent structure of the American Telephone and Telegraph Company if it could not make use of the modern improvements in long-distance telephony.

Is it sensible, then, to cut down on research activities in periods of temporary dullness, when these activities more than anything else provide the business foundation of an industrial organization?

Industry and Education at Lehigh

INDUSTRY and education got on famously together at Lehigh University for three days in October, when, on the occasion of the dedication of the Packard Laboratory, representatives of both of these important elements of modern life met for the dedicatory exercises and a significant conference on the relation between the industries and the technical schools and the future of American industry. Industry was given an opportunity to tell what it expected of engineering education, and educators in turn were permitted to say what they expected of industry, and finally both looked into the future at some common problems confronting them and the rest of the world.

It was established that the college-trained man is no longer persona non grata with the industries. This is a distinct victory for education from two points of view. Not only have engineering colleges been able to turn out a valuable product, but education and its fruits, increased knowledge, have so altered the industrial scene that an educated man is essential in industrial life.

There was adequate testimony to the desirability of adhering to a generalized curriculum and to the dangers in specialization. It is quite clear that highly specialized factual knowledge should be acquired after a decision as to the line of work a man is to follow has been made, and not while he is still undergoing his undergraduate experiences. Industry recognizes its own responsibility in this special training program, and in general is prepared to continue where the college left off.

Research is more strongly entrenched than ever—both in the school and in the university. No one now expects conditions to remain unchanged. Technological progress has intensified competition and hastened obsolescence, as well as having improved products and reduced costs and manual labor.

The supply of research workers is beginning to cause concern in some quarters. The industries are robbing the colleges of the best men in the teaching profession. They are draining the academic laboratories of the best research workers. Fear is expressed by some that industrial research may absorb those whose talents should be utilized in the fields of pure research, from which the most revolutionary discoveries are likely to come. And fear is also expressed that we shall be unable to develop a sufficient number of scientists of superior qualities, surrounded by the proper conditions, to make the immediate future as profitable in noteworthy discoveries as the past has been.

The problem of distribution, a scientific attack upon which is long overdue, also came in for careful scrutiny, and other economic problems, such as unemployment, were frequently mentioned. The worker in engineering and the physical sciences has advantages which make the problem of production a fairly simple and reasonably economical one. But the worker in the field of distribution combats ignorance and inertia in overwhelming numbers. He is confronted with complex social and economic problems which defy simple categorical solutions. What is he to do in the face of industrial depression? How can he predict human reactions or control individual whims and muddleheadedness? Yet there are those who do not despair of progress in this great phase of the industrial problem, and who predict that the scientific method may be applied to it with hope of success. To this problem these brave spirits invite the attention of engineers, because they feel that engineers, having made such a noteworthy success in production, have the necessary equipment to tackle distribution. The objective is a worthy one; we urge engineers to attempt it.

Dr. Daniel Adamson

DR. DANIEL ADAMSON, engineer and boilermaker, head of Joseph Adamson and Company, Hyde, Cheshire, England, and member of the A.S.M.E., died on October 11, 1930, following an operation. His life had been devoted to the activities of the business founded by his father, Joseph Adamson, who, as a manufacturer of boilers, had been influential in introducing the use of steel plates in the boilermaking industry and had initiated the practice of flanging boiler ends in the hydraulic press.

Dr. Adamson was born at Newton Moor, August 26, 1869. He received his early education in local schools. At the age of sixteen he was apprenticed to an engineering firm, carrying on his schooling simultaneously by attending evening classes. At the conclusion of this period of training in 1890 he was working in his father's works as foreman of the turning, fitting, and pattern shops.

In 1893 Dr. Adamson became works manager of Joseph Adamson and Company, and during this same year made a trip to America where he studied the development of electric transmission. On his return to England he put this experience to good use by producing through his company the first electric three-motor overhead crane, thus adding to the business an activity which became one of its major interests.

In 1902 Joseph Adamson took Dr. Daniel Adamson and a younger brother into partnership with him. The business was conducted by the two brothers after the death of the father in 1920, but a dissolution of the partnership in 1925 left Dr. Adamson as the sole proprietor. Boilers and electric cranes continued to be the principal output of the company. Dr. Adamson had recently devoted considerable attention to waste-heat recovery in boiler plants.

Dr. Adamson's first contribution to the literature of engineering was a paper read before the Manchester Association of Engineers in 1895, entitled "Electric Power Transmission," in which the results of the tests on his cranes were given. Besides his interest in this subject he took up the study of high-speed tool steels and served on a committee of the Manchester Association to investigate their use. A paper on "Wire Ropes" was read before the Institution of Engineers in 1912, and another on "Spur Gearing" won for him the Thomas Hawkesley Gold Medal in 1917. His paper on "Electric Cranes" before the Manchester Association of Engineers resulted in his receiving the Constantine Gold Medal in 1926.

Dr. Adamson was president of the Institution of Mechanical Engineers in 1929, during which year he was given the honorary degree of Doctor of Science by the University of Manchester. He was a member of numerous engineering societies in his own country, serving as president of the Manchester Association of Engineers in 1922. Aside from being a member of the A.S.M.E., he was also a member of the American Institute of Electrical Engineers, the American Welding Society, and the Association of Iron and Steel Electrical Engineers in this country.

Smoke Abatement in New Jersey

FOLLOWING the excellent example set by several communities in other parts of the country, Hudson County, New Jersey, is going in for smoke abatement. Fortunately the movement has been started under engineering direction, and

is to be set in motion by men who have had successful experience in other places. It is safe to predict that the campaign will be carried out along sane and practical lines.

For the activity in smoke abatement promising to take place in New Jersey, credit should be given, among others to Dr. Harvey N. Davis who evinced an interest in the matter soon after coming to Stevens Institute of Technology. He has been able to secure the advice and services of Elliott H. Whitlock, whose record as commissioner of smoke inspection in Cleveland has attracted much favorable attention. The engineering work will be under the direction of William G. Christy, for many years secretary of the Citizens Smoke Abatement League of St. Louis.

Persistence and eternally keeping after the nuisance must be practiced in smoke-abatement work. It is useless to hold a campaign over a period of months, correct evils, and then expect that they will stay corrected without further attention or effort. Any relaxation on the part of smoke inspectors and smoke-abatement commissioners will result in a return to the original offensive conditions. This has been shown time and again in communities where public interest has waned and public funds for the support of the work have gradually been cut off through political maneuvering or a false notion that the work has been completed. Ordinances and amendments to building codes do not have to be fought out every year, but unless they are enforced and unless offenders are watched, warned, and brought to book, and unless advice on proper methods is available through some recognized agency, like weeds spreading over an unattended garden the old nuisances will return and the good work that has been accomplished will be stifled and disappear. The job of smoke abatement is never done.

Claude's Tropical-Seas Power Plant

THERE are men to whom Kipling's qualification applies most strikingly—

> If you can trust your faith when all men doubt you,
> Yet make allowance for their doubting, too..........
> You'll own the earth, and what is more,
> You'll be a man, my son.

Claude's life is full of instances where he did things that every one considered to be next to impossible. The creation of the dissolved-acetylene industry was the first of his important achievements. Next came a new method of cryogenation by means of which gases such as oxygen and nitrogen were liquefied by an apparatus in which the energy of the gases was directly consumed in driving a piston. This was followed by the development of a method of producing synthetic ammonia by the use of enormous pressures, by his invention of the neon light, etc.

In all of this work Claude was never afraid of resorting to means beyond anything previously known or considered permissible. His new scheme of producing power by utilizing the comparatively slight difference between the temperature of the surface water of tropical seas and that of the water obtained from a considerable depth belongs to the same category of doing something in a way that no one dared attempt before on a sufficiently large scale.

That the process used by Claude can produce power is beyond doubt. In the first place, the principles lying at the foundation of the Claude development are well known and recognized, and in the second place, Claude has actually generated power both in his experimental plant in France and in the larger plant on the Cuban coast. The only question that still remains to be solved is whether or not this power can be produced economically—in other words, whether the plant will pay on its investment. From this point of view quite elaborate calculations have been offered showing that it will not pay. The following, however, has to be borne in mind. Claude, in addition to being an inventor, is an engineer with an excellent mathematical and physical training. He is assisted by Boucherot, a man of recognized engineering ability. The elementary calculations which have been cited against the project are of a kind which Claude himself has certainly made, simply because he could not have laid out his units without some such previous calculations. If, in the face of these he decided to go ahead with an experiment the cost of which will considerably exceed a million dollars, and when that million has come not from the sale of stock to the general public but from the proceeds of his own previous achievements, it behooves the engineering world to refrain from expressing doubt too actively. It is just the ability to see a possible way when every one else says there is no way at all, that distinguishes men like Claude who succeed from those who prove by arithmetical calculation that success is impossible.

Should Claude succeed, he may lay the foundation of an industrial and social revolution in tropical countries. It was only through the application of heat to houses that the temperate and cold zones became habitable, and we know now that with cheap power available the question of cooling houses is no more complicated than that of heating them—and cooled houses would make tropical countries freely accessible to extensive settlement by the white races. If Claude can provide cheap power without resorting to fuel, absent in most cases in the tropics, he may do for those regions what Prometheus of the legend did for the rest of the world.

Predictions Regarding Business Trends

PROFESSIONAL soothsayers found long ago that predictions of good times or events are better received than those of calamities. None of us has unbounded faith in the prophets of today, and the general opinion is that if a man must prophesy, he had better foretell nice things. Should the results prove to be different from what was predicted, there is at least the feeling that the prophet tried to please; while, on the other hand, if he foretells a calamity and the calamity comes to pass, there is a lurking feeling in the human mind that the prophecy may have had something to do in bringing it about. This applies, of course, more especially to fortune tellers and crystal gazers. When it comes, however, to predictions of trends of business events by responsible leaders of finance or politics, the public expects to be told the truth, or what is considered to be the truth, rather than to be soothed by rosy forecasts which do not eventuate.

From this point of view the course adopted in the last twelve months, that is, since the stock crash of October, 1929, has not been an edifying one. The first statements following the crash, and coming from the most prominent individuals in the country, were that we were dealing with what might be called a temporary adjustment of values. It was even intimated that this adjustment of values was a healthy one as it was going to bring the prices of securities more in line with their values as determined by their earnings. The crash was followed by a shower of declarations of regular and, in some cases, extra dividends by so-called market leaders, which were intended to act as a further assurance that everything was all right, or soon would be. Things have, however, not been right, and have steadily gone from bad to worse, and yet great bankers, industrial leaders, and Cabinet officers have come out with statements one after another telling the public that improvement is right around the corner. It may have been a coincidence, though not a happy one, that during the summer of 1930 each statement by a Cabinet officer predicting business improvement, was followed by a crash of prices on the stock exchange. As one man expressed it cynically, "It's the bulls and not 'bull' that raises prices."

Predictions and promises of improvement in business are of value only when they are conservatively stated, and should be formulated only when there is very good reason to believe that they are correct. Stimulating good times is very different from stimulating business to produce the good times, and today business is conducted on such an enormous scale that the influence of a personal statement is practically negligible unless its correctness is rapidly borne out by facts.

In England at the beginning of the World War the slogan was, "Business as usual." It was found out, however, that business could not be carried on as usual in a world torn by the greatest strife in its history. The depression which followed the realization of this fact has been admittedly much worse than would have been the case had the situation been frankly faced from the start and a rapid adjustment made. There is no question that with the enormous wealth accumulated in the United States and its natural advantages, good times are coming back. Any prediction to that effect cannot help being correct. But because we have great wealth in this country does not mean that boom times are coming back in one, three, or six months. Approximately one out of every eleven gainfully employed in normal times is out of a job today, and the proportion may increase to one out of nine before the winter is over. Such a situation cannot be overcome in a month or two, and it is a good thing for engineers to realize these facts. Business is coming back, but like a huge flywheel it will have to accumulate and store an amount of energy corresponding to its mass before it can attain its normal speed.

Student Engineers at French Lick

NOT since the memorable gathering at White Sulphur Springs in 1927 has the A.S.M.E. met at a resort until the French Lick meeting in October of this year. The program of technical papers was a diversified one, and included, according to custom, several dealing with local industries. Excursions added reality to the discussion of these topics.

Chief of the impressions that have been received from the meeting is that made by the members of numerous nearby student branches who presented papers at one of the sessions. It is a pleasure to record, with a word of commendation for the very excellent manner in which the paper was presented, the award of a prize of twenty-five dollars, offered by William A. Hanley manager of the A.S.M.E., to Allen G. Stimson, of Rose Polytechnic Institute, for his paper entitled "Mechanical Engineering in the Coal Industry."

Mr. Stimson and the other young men who competed for the prize—and it seems that the judges found difficulty in their decision because of the general excellence displayed by all contestants—have set a high standard for members of engineering societies to follow in the manner on which their papers were delivered. It is greatly to be hoped that the excellent showing by these young men at French Lick is an indication that the coming generation of engineers is to be more effectively expressive in public than the present generation has been. The training in English and in public speaking which is greatly emphasized in engineering curricula today is apparently bearing fruit. What more hopeful sign for the future could there be than this?

The coming years will demand much of the engineer that can be accomplished only by the persuasive methods of public presentation. The inarticulate engineer—so competent to plan, so incompetent to explain his plan—has oftentimes defeated his major purpose, final accomplishment, by being a poor advocate for himself and his profession. As life touches more and more on the province of engineering, the need for men who can adequately explain plans and lead the public to adopt well-conceived projects will increase, while in professional circles, anything that will raise the efficiency of distribution of technical knowledge is a great step forward. It is to be hoped that the example of these young men will be prominently called to the attention of all engineering students, and that older engineers will profit by it to the extent of improving their own methods of public address.

The A.A.A.S. Cleveland Meeting

SCIENCE is playing a greater rôle in history than ever before. Daily it becomes more important. It has got into the newspapers; it affects the lives of every one of us in countless ways. It blazes the trail for engineering and for industrial and social progress. It is the great cult of modern times. The extent of its domain is boundless; the variety of its interests is without limit. The zeal for truth pervades its workers and gives them common ideals; and in a great meeting, held every year during Christmas Week, these devotees of science come together to take stock of the year's grist of new-found truth and to experience the stimulation that comes from intellectual contact with other workers in their own and other fields. The American Association for the Advancement of Science offers this opportunity for yearly rejuvenation in its annual meeting, to be held, this year, at Cleveland, Ohio, December 29 to January 3.

The meeting will open on Monday evening, December 29, with the address of the retiring president, Dr. Robert A. Millikan. Other evening lectures of general interest will be the Sigma Xi lecture by Dr. C. E. K. Mees, whom members of the A.S.M.E. attending the Rochester Meeting of the Society in 1929 will recall with delight; and the Gibbs lecture which Dr. Edwin B. Wilson of Harvard University will deliver on Tuesday afternoon under the auspices of the American Mathematical Society.

Of especial interest to engineers will be the sessions of Section M (Engineering) on Tuesday and Wednesday. Wednesday afternoon the retiring vice-president of the section, Prof. H. F. Moore, of the University of Illinois, well known to readers of MECHANICAL ENGINEERING as a contributor to its pages, will deliver an address on "Engineering Culture." Other papers before this section will deal with recent developments in telephony, the mechanics of the telescope, the problem of sewage treatment and water purification, and some recent metallurgical developments. Here is an opportunity for engineers to renew their acquaintance with the sciences and to find out how their own problems are being affected by the studies of research workers.

Fifth Annual Wood Industries Meeting

THE fifth national meeting of the A.S.M.E. Wood Industries Division was held at the Pennsylvania Hotel in New York on October 16 and 17, and from every point of view was the most effective session ever conducted by that division. Approximately two hundred and fifty persons, over half of whom were A.S.M.E. members, were registered. Local publicity proved effective in bringing leading executives of large concerns to the meeting, and with them came many members of their engineering staffs.

The character of the papers presented repeatedly and emphatically indicated the need of more comprehensive and intensive research on the part of the woodworking industry. Every session had to be arbitrarily closed by the presiding officer before the discussions were complete, an impressive evidence of the unusual interest and attentive listeners. Papers discussing paints, improvements in saw steel, and standards in abrasive materials, as well as the two suggesting plastic wood products, were of unusual timeliness and elicited protracted discussion.

An innovation at the meeting was an exhibit of wood products and accessory equipment and supplies. This exhibit was arranged in an anteroom or foyer leading to the convention hall, and not only proved to be a decided success from the viewpoint of the exhibitors, but also supplied, in an unusually gratifying manner, an opportunity for members and guests to meet socially and discuss their various problems in a friendly and intimate way.

The luncheon meeting, at which the subject of tropical woods was discussed, was especially illuminating in revealing the wealth of tropical timber that is available when our domestic supply begins to falter. It is essential that the way be prepared by predetermining the strength and quality of these species, and thus make these woods of real service when needed.

The annual banquet was presided over by Dr. Wilson Compton, secretary-manager of the National Lumber Manufacturers' Association, and was devoted entirely to the subject of educational courses in colleges and technical schools for preparing wood engineers for executive positions. Leading educators from the Massachusetts Institute of Technology, the School of Forestry of the University of Michigan, The Forest Products Laboratory, and the New York State College of Forestry, as well as from a number of other institutions, were present and engaged in the discussions.

Much of the discussion was to determine whether the best way to produce woodworking engineers is by grafting engineering subjects on to a fundamental forestry training course, or by supplementing a fundamental engineering course with such wood-derivation and utilization subjects as may be required. In either case a substantial number of business-administration courses must be included.

It was pointed out at this meeting that the best way to develop fundamental and applied research in the wood-using industries is to offer courses in wood engineering at leading technical schools and make adequate arrangements, as well as afford financial interest, to attract undergraduate and graduate students into the almost virgin research field of the industry.

One morning was devoted to industrial excursions, and the leading wood-using industries in metropolitan New York were both cordial and generous in their welcome.

While the Wood Industries Division is one of the younger divisions of the Society, and is not large in numbers, it has given evidence of decided virility in the character of meetings it has held. It has planned to hold the next, or sixth, annual session in one of the southeastern woodworking centers.

THOMAS D. PERRY.

"Petroleum Mechanical Engineering"

THROUGH the enterprise and industry of the Petroleum Division and members of the Mid-Continent Section of the A.S.M.E., a successful meeting was held in Tulsa, Okla., on October 6 to 8. The papers presented at this meeting were preprinted in a publication called *Petroleum Mechanical Engineering*, and distributed to members of the Petroleum Division and offered for sale at the Tulsa meeting, held in connection with the Petroleum Exposition. Thus was inaugurated a determined effort to bring to the attention of mechanical engineers the problems in petroleum mechanical engineering that confront the industry and the profession.

The success of the meeting and an account of it are recorded in the October 22 issue of the *A.S.M.E. News*. In a report to the Council of the A.S.M.E. received at the meeting at French Lick, the history of the activities that culminated in the Tulsa meeting were set forth and the interest shown by the Council in the field of petroleum mechanical engineering was briefly reviewed. The following excerpt from the report summarizes the work accomplished by the Petroleum Division in the Tulsa district.

"As a result of this action,[1] Assistant Secretary Hartford returned to the Mid-Continent Area, and after developing certain committee work, negotiated with Prof. Wm. H. Carson, head of the department of engineering at the University of Oklahoma, to devote his full time during summer-vacation season to maintain committee activities and particularly to direct a field test on a steam rotary-drill rig. This being the first time any such test had ever been undertaken, it was necessary to assemble certain types of recording apparatus heretofore unused in the oil fields. Certain portions of the apparatus had to be designed and constructed for the proposition. After overcoming many obstacles, the necessary apparatus was assembled to the equipment of a contractor on an Indian-territory illuminating-oil company's well which started drilling in the Oklahoma City field the last week of September. Specific data are being recorded on a twenty-four hour basis with regard to the fuel consumption, water consumption, steam generated and used, and efficiency of slush pumps and other mechanical apparatus, so that upon completion of the drilling of the well there will be available for the first time a definite knowledge of these various phases of operation. It is the plan of the Committee that these data shall be studied sufficiently to make apparent any deficiencies which might exist. Incidentally, certain of the apparatus such as the engines being used on the job will be taken to the laboratory of the University of Oklahoma and subjected to a laboratory test, which in turn will give comparable data which can be utilized in connection with the figures obtained from the practical operating test.

"The Committee will then consider the wisdom of undertaking to design what might be termed a theoretical project, a steam drilling rig, and if the progress warrants so doing, will undertake to persuade a group of oil-producing companies to have such apparatus outlined, built, and used in drilling in the well, subject also to another test which will record actual operating conditions in the same way as is now being done with the standard steam drill rig. After the theoretical calculations thereof are justified, it is probable that the final result of the activities of this Committee will be to revolutionize the present rotary-drilling methods.

"While these several committees were carrying on the projects outlined, another group was actively engaged in developing a program of technical papers for presentation at the First National Petroleum Division of the A.S.M.E. meeting, which was held in the auditorium on the grounds of the International Petroleum Exposition during the seventh renewal of that stupendous demonstration of apparatus used by the petroleum industry. Twenty-five papers of unusual value and interest were prepared and presented. . . .

"The automatic pipe-line station proved to be one of the outstanding features of the Petroleum Exposition, and attracted more attention by its uncanny functioning, especially through its remote-control station and apparatus, whereby it was operated theoretically at a distance of fifty miles over telephone, while such demonstrations were recorded as the shutting down of the plant due to a hot bearing, or the reversal of the pumps due to a break in the line and the sucking back into the station's supply tanks of the oil in the pipes between the station and the point at which the break occurred; or the more than human functioning of the apparatus whereby when all valves were set diametrically opposite to their accustomed position and the current was turned on that automatically rectified themselves and proceeded to operate."

[1] That taken by Council of A.S.M.E. at its Detroit meeting in June, 1930.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Applications of X-Rays

LES APPLICATIONS DES RAYONS X. By J. J. Trillat. Les Presses Universitaires de France, Paris, 1930. Cloth, 6 × 9¼ in., 298 pp., 85 francs.

THE author of this book is well known both for his work in the field of X-rays and for his investigations on lubrication. The work consists of two parts. The first deals with the production and application of X-rays and X-ray apparatus, and is of interest to Americans because it describes European apparatus not generally known here. Of far greater interest, however, is the second part, dealing with the X-ray investigation of complex organic compounds, colloidal matter, cellulose and its products, rubber, gelatine, proteins, etc. On each subject the author gives a short bibliography, taken practically exclusively from German and French publications. The author apparently is not at all familiar with some of the American work done on the same subjects. The most interesting part of the book is Chapter 6, dealing with an investigation by means of X-rays of the liquid state and the mesomorphous state, a subject on which extremely little information is available.—L. C.

Quantum Mechanics

QUANTUM MECHANICS. By Edward U. Condon and Philip M. Morse. McGraw-Hill Book Company, Inc., New York, 1929. Cloth, 6 × 9 in., 250 pp., 28 figs., $3.

THIS book is of interest because it aims to give an account of some of the leading developments in our knowledge of atomic structure and the interpretation of spectroscopic and electronic phenomena which have been made in the past ten years.

As a matter of fact, quantum mechanics is a very young science, having come into existence only about five years ago. Since then, however, it has had a tremendous development and has revolutionized not only our conceptions of physics, chemistry, and astronomy, but also of many fields of mathematics. Because of this and also because of the fact that it is still in a state of vigorous flux, it is a subject which is largely a closed book to the average layman.

The authors have endeavored to present the subject in as simple a manner as possible and have largely succeeded in their attempt. It is of interest to note, however, that certain theories which are assuming a major importance as time goes on, have been, probably of necessity, only briefly touched upon in the book. This applies in particular to the mathematical theory of tensors and the statistical theory such as that proposed by Heisenberg, although the authors do not mention the indetermination principle of the latter.

For those who wish to obtain a clear and reliable idea of quantum mechanics but are not equipped to handle the highest mathematics, the present book will be unquestionably valuable.—L. C.

Sheet Steel and Tin Plate

SHEET STEEL AND TIN PLATE. By R. W. Shannon. Book Dept. of The Chemical Catalog Company, Inc., New York, N. Y., 1930. Cloth, 6 × 9 in., 285 pp., $5.

THIS book is largely of a practical nature. In the introduction it gives some general ideas as to the fundamentals of steel metallurgy. Further on, however, particularly in the part dealing with rolling, the text is limited to a description of the methods used, leaving out entirely the mathematics of sheet rolling and such things as the question of loads on bearings. In doing so the author has produced a valuable book containing a large amount of practical information not to be found in print elsewhere. This applies particularly to the part beginning with Chapter 6. Some parts are treated somewhat sketchily: for example, continuous hot rolling of sheets, the most revolutionary development in the industry in years, occupies less than ten pages; and cold-process rolling, another promising development has been left out completely. Nevertheless the book represents a valuable contribution, is well written, and apparently is free from misstatements.—L. C.

Strength of Materials

STRENGTH OF MATERIALS. Part I, Elementary Theory and Problems; Part II, Advanced Theory and Problems. By S. Timoshenko. D. Van Nostrand Co., Inc., New York, 1930. Cloth, 6 × 9 in., Part I, 368 pp., 299 figs., $3.50; Part II, 336 pp., 175 figs., $4.50.

REVIEWED BY H. F. MOORE[1]

TEXTBOOKS on the resistance of materials vary in character from elementary works suited to students in trade schools to those employing the elaborate methods of the mathematical elasticity of materials and requiring a knowledge of differential equations and other ultra-calculus branches of mathematics. Professor Timoshenko's book may be characterized as an elaborate treatise, which nevertheless can be followed by any student

[1] Research Professor of Engineering Materials, University of Illinois, Urbana, Ill. Mem. A.S.M.E.

having a knowledge of calculus. It would be a rather difficult book for the average junior in an American engineering college, but it is an excellent one for the advanced student, and for the library of the structural and machine designer. It has distinctly the flavor of the European textbooks, and is characterized by a rather austere mathematical tone.

The book is published in two volumes. The second volume is given over mainly to more advanced problems and brief discussions of the properties of materials. It is of interest to note that the author has put the subject of the buckling of columns, plates, and tubes into this second part.

The author introduces his chapters on impact by a discussion of the energy of strain. He gives an up-to-date discussion of theories of failure, and emphasizes the use of the Mohr diagram, —a tool for computation which has received rather scant notice in this country.

The typographical make-up of the book is good. Certain parts which may be omitted, if necessary, are printed in small type. Numerous references are given, a large proportion of them being to foreign sources and unfamiliar to most American students of engineering materials. The cross-references between Part I and Part II are numerous and helpful.

Whether the average American junior engineering student could with advantage begin his study of strength of materials using so "stiff" a text as Professor Timoshenko's is an open question, but the book will certainly be of great value to the advanced student, the teacher, and the designers of structures and machines.

Applied Mechanics

APPLIED MECHANICS. By Frederic N. Weaver. The Ronald Press Company, 1930. Cloth, $5^3/_4 \times 8^3/_8$ in., 322 pp., 307 figs., $3.25.

REVIEWED BY J. ORMONDROYD[2]

TEACHERS of elementary mechanics should welcome this book because it is less than half the length of the usual engineering text on the subject. This brevity has been gained by the logical conciseness of the developments and by the exclusion of several topics which the author rightly concludes belong properly in the field of machine design or in a course of advanced mechanics. The book is illustrated profusely with diagrams. The number of illustrative and practice problems is greater in proportion to the text than in most textbooks on the same subject. Of especial interest from the pedagogical viewpoint is the fact that a numerical answer is given immediately at the end of the statement of each problem. This guides the student without lessening his responsibility in the actual application of the principles involved in the problem. The emphasis is put where it belongs—in the method of attack rather than in the answer. The book is of a handy size and very attractively printed; the good psychological effects of these things on the student cannot be overemphasized.

Professor Weaver's little historical sketch in the first chapter can only be criticized because it is too brief. The outlook there indicated is nearly always lacking in textbooks, and its inclusion helps to add to the attractiveness of the work.

Throughout the book there is evidenced a broad scientific attitude—generalizations, limitations. fine distinctions are hinted at here and there which one usually does not find in such a volume.

A combination of logical outlook and esthetic taste has moved Professor Weaver to exclude tables of values such as are found in machine-design texts. Perhaps logic has been strained somewhat in relegating the loaded cable to an appendix, since the theory of the loaded cable makes a beautiful application of the simple triangle of forces. Inasmuch as the application of statics in this case is not as immediate as in the rest of the text and the expressions arrived at are more complicated, perhaps it is good taste to separate it from the body of the book.

Centers of gravity and moments of inertia are concepts used over and over again in mechanics. They are not fundamental principles, and for this reason Professor Weaver has put the analytical methods of calculating these quantities in an appendix. These chapters might have been made more complete by adding graphical methods of calculation. However, this is one of the things which had to be sacrificed in the achievement of brevity. Professor Weaver has developed the concept of mass moment of inertia in the text in a simple and natural manner by the use of ideas already familiar to the student from his studies of linear motion. This is a refreshing relief from the usual dry and seemingly arbitrary definition nearly always given.

One is often tempted to ask why it is that moment and moment of inertia are always given to the student as mathematical definitions and not as physical concepts. Moment in one of its original meanings signified importance, and the term "moment" in dynamics indicates the importance or effectiveness of a force in producing or resisting angular accelerations. A little historical comment such as this certainly has more life than a pure definition.

Professor Weaver in company with other writers merely states Newton's laws. Most students look upon these laws as axioms to be taken on faith—mysteriously handed down like the tablets from Sinai. A slight reference to Galileo's rolling marbles on ascending inclined planes would immediately put reason and life blood in these (to the student) drab concepts. The student is always yearning to have new ideas connected logically with life in simple terms as he knows it, and only the history of the original conception can do this.

In the chapter on friction, Professor Weaver uses pressure as meaning total force. To engineers, pressure has the fixed technical meaning of force intensity—pounds per square inch, for instance.

Some groups in the past laid down the law that the units of measurement in engineering are the pound, the foot, and the second. Professor Weaver gives all his problems in feet, to comply with this law. Engineers, however, are "scofflaws"—they persist in using the inch as the unit of length. All drawings of machinery have dimensions in inches, all physical properties of material are given in inch units, water and gas pressures are given in inch units, and g is 387 instead of 32.2 to those of us who apply dynamics to the study of vibrations.

Again, engineers invariably talk in terms of frequency, not in terms of period for periodic quantities; r.p.m.; cycles per second; paydays once a week or twice a month, and so on. But every textbook, including this one, talks about the period of a pendulum swing. Periodic motions, or vibrations, by the way, are about the most important reasons for the present-day engineers' studying dynamics. In spite of this, all textbooks consider these motions no further than the theory of the free oscillation of the compound pendulum. All the developments since Huyghens' time are ignored. This omission is inherent in the system which does not consider differential equations as a necessary part of an engineer's education.

As Professor Weaver remarks in his preface, "the general content of courses in applied mechanics is pretty well standardized .... in American engineering colleges." Within the limitations of this standardization, this little book can be considered excellent.

[2] Experimental Division Manager, South Philadelphia Works, Westinghouse Elec. & Mfg. Co.

Books Received in the Library

AIDE-MEMOIRE. By J. Claudel. Twelfth edition. Dunod, Paris, 1930. Cloth, 5 × 9 in., 2 vols., 2296 pp., illus., diagrams, tables. 259. 60 fr., 2 vols.

This well-known handbook, first published in 1846, appears in a newly revised edition. Little change has been made in its scope, the principal emphasis still being upon hydraulic engineering, roads, railroads, and sanitary engineering, but there are sections devoted to mechanics, industrial physics, steam and gas engines, and electrical engineering. A useful summary of current French practice.

AIRCRAFT INSTRUMENTS. By C. J. Stewart. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 269 pp., illus., plates, tables, $5.50.

Treats of the design, construction, functioning and fitting of the instruments needed by the pilot to inform him as to his speed, altitude, position, and the condition of his engine. The author is in charge of aircraft-instrument design for the British Air Ministry.

APPLIED MECHANICS. By Norman C. Riggs. Macmillan Company, New York, 1930. (Engineering Science Series.) Cloth, 6 × 9 in., 328 pp., $3.75.

A college textbook based on the course given to engineering students at the Carnegie Institute of Technology. A working knowledge of integral calculus is assumed. Emphasis is directed toward material of engineering interest.

APPRAISERS AND ASSESSORS MANUAL. By W. L. Prouty, Clem W. Collins, and Frank H. Prouty. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 500 pp., illus., tables, $5.

A guide to the valuation of land, buildings, machinery, merchandise, and personal property, especially with appraisals for purposes of taxation. Describes a wide variety of systems and methods which are in use, and contains many data on costs and depreciation.

BEITRAG ZUR FRAGE DES AUSBEULENS VON VERSTEIFTEN PLATTEN BEI SCHUBBEANSPRUCHUNG. By Edgar Seydel. (Luftfahrtforschung, vol. 8, no. 3.) R. Oldenbourg, Munich and Berlin, 1930. Paper, 8 × 11 in., 20 pp., diagrams, tables, 4.20 r.m.

The author develops a formula for determining the critical load of corrugated or stiffened plates subjected to compression.

BERECHNUNG UND KONSTRUKTION DER DAMPFTURBINEN. By C. Zietemann. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 452 pp., illus., diagrams, 33 r.m.

Aims to give a comprehensive, connected exposition of the principles, design, and construction of steam turbines, with examples selected from current practice. Chapters are devoted to the thermodynamic principles, turbine design, the design and construction of single parts, governing, turbine types, and turbines for special purposes. The use of methods is illustrated by many solved problems. The book is an excellent introduction to the subject.

BERICHTE ÜBER BETRIEBSWISSENSCHAFTLICHE ARBEITEN, vol. 3. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 11 in., 35 pp., illus., diagrams, tables, 8.50 r.m.

This series is devoted to problems that arise in machine-shop practice and metal working, and is a companion to the "Forschungsarbeiten auf dem Gebiete des Ingenieurwesens." The present papers give the results of investigations of the efficiency of various cooling liquids and lubricants for lathe tools, of the practical value of additions of graphite to lubricating oils, and of the effect of rounding the corners of sheet-metal drawing dies.

BERICHTE ÜBER BETRIEBSWISSENSCHAFTLICHE ARBEITEN, Vol. 4. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 11 in., 45 pp., illus., 10 r.m.

Contains the addresses delivered at a meeting of the metal-working section of the Verein Deutscher Ingenieure. The addresses all have to do with the cutting of metals; they include a critical review of the research work carried out in this field during recent years; a description of a novel electrical process for the measurement of chipping; and the results of a recent investigation of milling cutters.

BESTIMMUNG DER ROHRWEITEN VON HOCHDRUCK-, NIEDERDRUCK- UND UNTERDRUCK-DAMPFLEITUNGEN. By Johann Schmitz. Second edition. R. Oldenbourg, Munich and Berlin, 1930. Paper, 10 × 13 in., 5 pp. text, 18 tables, 4.50 r.m.

These tables are conveniently arranged for determining the proper sizes of pipe for all ordinary steam-heating installations.

ECONOMIC RHYTHM: a Theory of Business Cycles. By Ernst Wagemann. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 287 pp., diagrams, charts, tables, $3.

This book aims to present the nature and method of action of business cycles and other economic trends, with the various theories that have been advanced concerning them; and also to assemble the material essential to future study. The author is a well-known authority in the field.

DER EHRENSAAL DES DEUTSCHEN MUSEUMS. By W. Exner. (Deutsches Museum Abhandlungen und Berichte, vol. 2, no. 2.) V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 64 pp., portraits, 1 r.m.

A brief guide to the Hall of Honor of the Museum, with a list of the noted scientists and engineers represented; and reproductions of some of the portraits.

ENGINEERING MATERIALS, vol. 3: Theory and Testing of Materials. By Arthur W. Judge. Isaac Pitman & Sons, New York, 1930. Cloth, 6 × 9 in., 498 pp., illus., diagrams, tables, $6.

A connected general account of the theory of the strength properties of materials, intended to call attention to the importance of specifications, and the methods of testing. Among the topics discussed are the effect of temperature upon strength, modern theories of materials, fatigue strength, optical methods of determining stresses, and the testing of cast iron.

ESSAI D'HYDROGÉOLOGIE. By Ed. Imbeaux. Dunod, Paris, 1930. Cloth, 8 × 11 in., 704 pp., illus., maps, tables, 297.10 fr.

Dr. Imbeaux here brings together the results of his long experience in this treatise on hydrology. Methods of determining the presence and amount of underground water, its quality and properties, are given, together with a survey of hydrological conditions in western Europe and the United States.

EXPERIMENTELLE UNTERSUCHUNGEN AN SCHNELLAUFENDEN KLEINMOTOREN. By Albert Geissler. R. Oldenbourg, Munich and Berlin, 1930. Paper, 6 × 9 in., 69 pp., illus., diagrams, tables, 5 r.m.

Gives the methods used and the results obtained in an investigation of small high-speed internal-combustion engines. The exhaust losses and the efficiency of fuel utilization were investigated in a two-cycle engine with crankcase compression, and the mathematical relations developed. An appendix gives the results of comparative tests of four-cycle and two-cycle engines of the same size.

FORMATION AND PROPERTIES OF BOILER SCALE. By Everett P. Partridge. (Engineering Research Bulletin, no. 15.) University of Michigan, Department of Engineering Research, Ann Arbor, June, 1930. Paper, 6 × 9 in., 170 pp., illus., diagrams, tables, $1.

This monograph is intended to be a complete review of the information now available upon its subject. It deals with the effects of scale upon boiler efficiency and boiler-metal temperature, with the chemical and crystallographic determination of scale constituents, with the respective solubilities of these constituents, with the method and rate of scale formation, and with contemporary methods of scale prevention.

GASFERNVERSORGUNG. (Kohle, koks, teer, bd. 23.) By August Kemper. Wilhelm Knapp, Halle (Saale), 1930. Paper, 6 × 9 in., 122 pp., maps, graphs, tables, 10.20 r.m.

A comprehensive monograph upon the problem of long-distance transmission of coal gas, with special attention to its economic factors.

GENERATING STATIONS: Economic Elements of Electrical Design. By Alfred H. Lovell. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 359 pp., illus., diagrams, tables, $4.

Explains the way in which economic principles are applied in the selection of apparatus for power plants and transmission systems, in proportioning the details of an assembly, and in balancing initial and subsequent costs. Attention is given to the interrelation of mechanical and electrical elements of the design, and the special features for which the electrical engineer alone is responsible are analyzed in detail.

GEOCHEMIE DER ERDÖLLAGERSTÄTTEN. By Karl Krejci-Graf. (Abhandlungen zur praktischen Geologie und Bergwirtschaftslehre, vol. 20.) Wilhelm Knapp, Halle (Saale), 1930. Paper, 6 × 9 in., 56 pp., tables, 5.50 r.m.

An elaborate study of the composition of the bituminous compounds found in oil fields and of the by-products of oil formation. The object is to throw light upon the formation of petroleum.

GEWICHTSVERLEGUNG UND AUSNUTZUNG DES REIBUNGSGEWICHTES BEI ELEKTRISCHEN LOCOMOTIVEN MIT EINZELACHSANTRIEB. By H. G. Lindner. (Forschungsarbeiten, no. 333.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., 25 pp., illus., tables, 5 r.m.

A study undertaken to determine the arrangement of motors and springs which will most effectively utilize adhesion. Calculations are given for all the usual varieties of electric locomotives of the type in question, as well as tables showing the results.

HARVARD BUSINESS REPORTS: Compiled by and Published for the Graduate School of Business Administration. Harvard University: vol. 8; Cases on the Motion Picture Industry, with commentaries by Howard Thompson Lewis. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 687 pp., $7.50.

The sixty-six cases in this volume present actual problems in the motion-picture industry and the methods by which they have been met and solved. Many of the administrative problems discussed have their counterparts in other types of business.

HEAT ENGINES. By Charles N. Cross. Macmillan Co., New York, 1930. (Engineering Science Series.) Cloth, 6 × 9 in., 607 pp., illus., tables, $6.

The author has endeavored to prepare a textbook that would contain within reasonable bounds an adequate treatment of the fundamental laws of gases and the laws of thermodynamics, together with descriptions of the modern forms of prime movers, their operating characteristics, and representative performance results of each type and size. The work represents the course at Stanford University. It is attractively written and illustrated. An unusually large amount of space is given to steam turbines.

INGENIEUR-ARCHIV, vol. 1, no. 1; Dec., 1929. Julius Springer, Berlin, 1929. Papier, 8 × 11 in., 122 pp., 9.60 r.m.

A new periodical, edited by Prof. R. Grammel of the Stuttgart Technical High School, which will appear at irregular intervals. The magazine will endeavor to promote intercourse between scientific research and engineering practice, especially the relations of mechanics and thermodynamics to mechanical and structural engineering.

The first number contains eight papers presenting the results of recent research work upon such questions of importance as the strength of cylindrical shells under loads that are not axially symmetrical, the unsymmetrical bending of thin circular plates, and the stresses in shaft timber.

JAHRBUCH DER WISSENSCHAFTLICHEN GESELLSCHAFT FÜR LUFTFAHRT E. V., 1929. R. Oldenbourg, Munich and Berlin, 1930. Cloth, 9 × 12 in., 227 pp., illus., diagrams, 26 r.m.

Contains the proceedings of the eighteenth meeting, a list of members and officers, and the papers presented before the society. Among these are papers upon the Do-X airship, the development of the Junkers airplane oil-engine, riveted joints in thin sheets, the use of electron in airplane construction, long-distance flying, and other topics of current interest.

DIE KRAFTWIRTSCHAFT, vol. 1. By Hans Balcke. R. Oldenbourg, Munich and Berlin, 1930. Cloth, 6 × 9 in., 680 pp., illus., diagrams, plates, tables, 38 r.m.

A practical treatise on planning and erecting power plants. The first volume discusses the technical elements of steam, internal-combustion, and hydraulic plants, and their combination in plant design. The book gives a good survey of modern practice in Germany.

KURBELWELLENBRÜCHE UND WERKSTOFFRAGEN. By Kurt Matthaes. (Luftfahrtforschung, vol. 8, no. 4.) R. Oldenbourg, Munich and Berlin, 1930. Paper, 8 × 11 in., 30 pp., illus., 6.20 r.m.

The author has investigated the problem of crankshaft breaking in six-cylinder straight-line aircraft engines. He concludes that the breakage is caused by defects in construction, not by faulty material.

LUFTFAHRTFORSCHUNG, vol. 8, no. 2. R. Oldenbourg, Munich and Berlin, 1930. Paper, 8 × 11 in., 32 pp., illus., tables, 6.60 r.m.

Researches on the dynamic strength of the varieties of wood used in airplanes, on the suitability of various varnishes for its protection, on glues for aircraft, and on the life expectancy of plywood for such work.

MACRAE'S BLUE BOOK AND HENDRICKS COMMERCIAL REGISTER, vol. 38, 1930. MacRae's Blue Book Co., Chicago and New York, 1930. Cloth, 9 × 11 in., 3308 pp., $15.

This well-known directory supplies an extensive list of manufacturers of materials and machinery of all kinds, classified by products; a directory of manufacturers and dealers, a list of trade names; and a gazetteer of towns with a population of one thousand or more, with information on their trade facilities. A special section, added for the first time, gives the same information for Canada.

MECHANICS: A TEXTBOOK FOR ENGINEERS. By James E. Boyd. Second edition. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 384 pp., illus., diagrams, $3.50.

This text aims to emphasize fundamental principles, illustrate

them by examples designed for that purpose, and to supply problems that will train the student in their application. Algebraic and graphical methods are developed concurrently in statics, as are work and energy, and force and acceleration, in kinetics. The new edition has been rearranged and partly rewritten, and revised by the inclusion of the British unit of work, the slug.

MECHANICS FOR STUDENTS OF PHYSICS AND ENGINEERING. By Henry Crew and Keith K. Smith. Macmillan Co., New York, 1930. Cloth, 6 × 9 in., 371 pp., diagrams, tables, $4.

A presentation of the fundamentals of mechanics adapted to the time usually allotted to the subject in engineering colleges. Vectorial methods are used freely, and an essentially historical method of presentation adopted.

MODERN PHYSICS; A general survey of its principles. By Theodor Wulf. Translated from the second German edition by C. J. Smith. E. P. Dutton & Co., New York, 1930. Cloth, 6 × 10 in., 469 pp., $10.

The educated reader in search of an account of physics will find his needs fully met by this admirable coordinated account of its fundamental results. The style is clear, non-mathematical and readable. The leading facts are clearly brought out and technicalities and small details are avoided. Those who wish to become acquainted with the results of physics, or who must utilize and consider them in their daily work, will welcome this survey.

NOTES ON SCREW GAUGES. By the Gauge-Testing Staff of the Metrology Department of the National Physical Laboratory. Third edition. His Majesty's Stationery Office, London, 1930. Paper, 7 × 10 in., 88 pp., illus., tables, 4s.

The purpose of these notes is to assist firms that are unfamiliar with the accuracy required in the manufacture and testing of screws. The pamphlet describes the principles underlying the practice of limit gaging as applied to parallel screw threads, the types of error met with in screw gages, and modern methods of testing these gages. The data required for making tests are included.

OBJECTIVE TYPE TESTS IN ENGINEERING EDUCATION AS APPLIED TO ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY. By Clair V. Mann. McGraw-Hill Book Co., New York, published for Engineering Foundation, Inc., 1930. Cloth, 6 × 9 in., 122 pp., illus., charts, tables, $2.75.

Presents tests in engineering drawing and descriptive geometry developed and used at the Missouri School of Mines to determine aptitudes and previous training on the part of entering students, and also to measure their classroom accomplishment. The book describes the tests and the methods of using them and gives a number of representative tests.

ÖSTERREICHS ZUKÜNFTIGE ENERGIEWIRTSCHAFT. By Richard Hofbauer. (Österreichsiches Kuratorium für Wirtschaftlickheit. Veröffentlichung 2.) Julius Springer, Vienna, 1930. Paper, 6 × 8 in., 87 pp., diagrams, maps, tables, 2.80 r.m.

A report on the probable development of power utilization The available sources of energy—coal, oil, wood, and water are appraised, the future requirements of the various industries are estimated, and the best method of utilizing the available power are discussed.

PLANT LOCATION. By W. Gerald Holmes. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 275 pp., maps, tables, $3.

The author has endeavored to outline a logical plan for investigating the desirability of different locations and to indicate a method for evaluating them. The choice of a general region, of a community, and of a site are considered in turn, and the factors to be considered, with the dangers to be avoided, are discussed.

PETROLEUM ENGINEERING HANDBOOK, 1930. *Petroleum World*, Los Angeles, 1930. Fabrikoid, 8 × 11 in., 495 pp., illus., diagrams, tables, $5.

A collection of articles which cover very fully methods and operations of petroleum production as practiced in California. Spacing of wells, methods of drilling and casing, treatment of field emulsions, pumping, repressuring, transportation, natural-gasoline metering, and other topics are discussed by specialists. Numerous tables, formulas, and nomographic charts are included.

TEXTBOOK OF THE MATERIALS OF ENGINEERING. By Herbert F. Moore. Fourth edition. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 409 pp., illus., diagrams, tables, $4.

A concise elementary presentation of the physical properties of the common materials, with brief descriptions of their manufacture and uses, intended as a textbook for technical students. In the new edition several chapters have been rewritten and a new one, on the crystalline structure of metals, added. Other parts of the book have been extended and revised.

THEORY OF THE POTENTIAL. By William Duncan MacMillan. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 469 pp., $5.

Designed for students of mathematics and of mathematical physics, this book is intended to give a connected account which will serve as an introduction to the subject and stimulate the cultivation of this useful field of mechanics.

THEORETISCHE PHYSIK. By Gustav Jäger. Vol. 1, Mechanik. Vol. 2, Schall u. Wärme. Vol. 3, Elektrizität und Magnetismus. Vol. 4, Optik. Vol. 5, Wärmestrahlung, Elektronik und Atomphysik. Walter de Gruyter & Co., Berlin and Leipsig, 1930. Cloth, 4 × 6 in., 5 vol., 180 r.m. each.

These five small volumes, by the professor of physics at Vienna University, are a concise, but comprehensive, survey of modern theoretical physics. This new edition has been rewritten and rearranged, as well as enlarged, and space has been found for the latest developments.

DIE VENTILATOREN. By E. Wiesmann. Second edition. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 309 pp., illus., diagrams, tables, 24 r.m.

A text on the design, construction, and uses of centrifugal blowers. Theoretical principles are developed quite fully, and the data and formulas needed by designers are presented. A number of large installations for ventilating tunnels and mines, for heating and drying, and for conveying are described.

WIRTSCHAFTLICHE MÖGLICHKEITEN DER MASCHINEN-UNTERHALTUNG IN LANDWIRTSCHAFTLICHEN GROSSBETRIEBEN. By Friedrich Buschmann. V.D.I. Verlag, Berlin, 1930. Paper 8 × 12 in., 39 pp., diagrams, tables, 3 r.m.

The advantages of machinery in farming can be realized only when facilities exist for economical repairs. In the present work the author investigates repair practice at a number of large German farms and discusses the advantages of various methods of maintenance, methods of ascertaining the true cost of machine farming, and ways of deciding when machinery will be profitable.

Erratum

On page 984, of the November issue in the fifth paragraph of Mr. Dilot's paper "How Safe Is a Factor of Safety?" the phrase "most lightly stressed part" should read "most *highly* stressed part."

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AERODYNAMICS

Modern German Research. Modern Aerodynamical Research in Germany, J. W. Maccoll. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 34, no. 236, Aug. 1930, pp. 649–679 and (discussion) 679–689, 18 figs. Important results of modern German research upon motion of incompressible fluids; theory of boundary layer and its application for laminar and turbulent conditions; experimental and theoretical investigation of development of turbulence; characteristics of fully developed turbulence: spreading of jets; flow in pipes and channels; convergent and divergent channels; flow between rotating cylinders.

AIR PREHEATERS

Kablitz. Kablitz's Air Preheater (Kablitz' Luftfoervaermare), H. Fahrbach. Teknisk Tidskrift (Stockholm), vol. 60, no. 38, Sept. 20, 1930, pp. 125–128, 8 figs. Preheater is described and compared with Green's economizer; by combination of economizer and air preheater 82 per cent efficiency has been obtained in boiler plant, and by using regenerative air preheater in stack even 90 per cent.

AIRPLANE ENGINES

Air-Cooled. Some Recent Progress in Air-Cooled Aero-Engine Development, C. F. Abell. Engineering (Lond.), vol. 130, no. 3373, Sept. 5, 1930, pp. 308–311, 7 figs. To summarize progress made in 10 years, weight per horsepower has been reduced by 25 per cent, power output increased by 50 per cent, and period between overhauls increased by 700 per cent, with corresponding increase in reliability of engine and life of main components; recent changes in design which have led to higher speeds of revolution, higher brake mean-effective pressure, and higher overall efficiency in Jupiter radial engine. Paper read before Section G of Brit. Assn. Sept. 4, 1930.

Diesel. Air-Cooled Heavy Oil Engines, A. H. R. Fedden. Aircraft Eng. (Lond.), vol. 2, no. 20, Oct. 1930, pp. 261–262, 3 figs. Experiments on single-cylinder 4-cycle airless-injection engine of $8^1/_2$ liter capacity and $7^3/_4$ by 12 in. bore stroke; for maximum fuel injection of 0.54 cc. engine developed, 77 b.hp. at 1100 r.p.m.; fuel consumption of 0.446 lb. per b.hp-hr. at 108 b.m.e.p.; graph shows comparative weight curves for compression-ignition and gasoline engine installations. Paper read before Fifth Int. Air Congress, Hague.

The Packard Diesel Aircraft Engine, L. M. Woolson. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 279–281 and 319. Discussion of paper previously indexed from Apr. 1930, issue of same Journal; elimination of fire hazard; ability to use crankcase oil as emergency fuel; advantages of two-stroke Junkers engine as compared with four-stroke Packard.

Liquid-Cooled. Possibilities of the Liquid-Cooled Aircraft Engine, R. B. Beisel. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 403–407. Advantages of liquid cooling as compared to air cooling; reduced resistance ethylene-glycol cooling; reduction in cooling-surface area; adaptability to gearing and high engine speed; characteristics of future engine visualized.

Radial vs. In-Line. In-Line versus Radial Aircraft Engines, W. F. Davis. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 451–453, and (discussion) 454–458. Comparison of advantages with regard to reliability, simplicity of design, weight, visibility, head resistance, installation and service costs; discussion relates experiences with ethylene-glycol cooling; carbureter location.

Supercharging. Geared Centrifugal Superchargers for Airplane Engines, S. A. Moss. Soc. Automotive Engrs.—Jl., vol. 27, no. 2, Aug. 1930, pp. 148–153 and 160, 13 figs. and (discussion), no. 3, Sept. 1930, pp. 340–343. Discussion of design and functioning of General Electric supercharger used in Pratt and Whitney, Curtiss, and Wright engines; notes on development and advantages; supercharging at sea-level and at altitude; maintenance of carburetor efficiency.

AIRPLANES

Autogiros. See AUTOGIROS.

Dope. Airplane Dopes and Lacquers and Their Application, W. W. McCutcheon. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 263–266 and (discussion) 266–267, 1 fig. General outline of composition, process of manufacture, and application of dopes, lacquers and pigmented dopes, and trouble experienced with available materials; simple and cheap methods of testing dope to ascertain its qualities are explained; primary requisites of good dope and cause and remedy for blushing.

Fuels. Fuel Problems in Aviation Engines, G. W. Vaughan. Oil and Gas Jl., vol. 29, no. 19, Sept. 25, 1930, pp. 38 and 76. President of Wright Aeronautical Corporation deplores fact that knock rating, characteristic that most interests aircraft engine builders, is not definitely and accurately covered by existing specifications; thing that must control design of standard engine that goes into general service is anti-knock value of poorest fuel that operator may buy under indefinite and misleading name of domestic aviation gasoline; unsatisfactory situation is holding back commercial development of new industry. Read before Nat. Petroleum Assn.

The Effect of Airplane Fuel-Line Design on Vapor Lock, O. C. Bridgeman and H. S. White. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 444–450 and 458, 9 figs. Measurement of flow through systems of various designs; increases in cross-sectional area along direction of flow are particularly liable to cause vapor lock; weathering of gasoline in carburetor float bowl reduces vapor-locking tendency; fuel-pump experiments.

The Vapor-Locking Tendency of Aviation Gasolines, O. C. Bridgeman and H. S. White. Soc. Automotive Engrs.—Jl., vol. 27, no. 2, Aug. 1930, pp. 218–230 and (discussion) 230–233, 20 figs. Study of properties of gasolines which determine their vapor-locking tendency; conditions under which vapor lock occurs in typical fuel feed of vapor lock; measurement of temperatures existing in fuel-feed systems of representative aircraft during flight.

Landing Speeds. An Investigation of Airplane Landing Speeds, K. F. Ridley. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 349, Sept. 1930, 39 pp. 21 figs. Performance characteristics; experimental work in measuring landing speed of several monoplanes by new photographic method; tests supplemented by available information regarding biplanes were compared with predictions made in accordance with basic aerodynamic theory; fundamental relation between wing loading, lift coefficient and speed of level flight, and effects of aspect ratio and proximity to ground on lift curve slope.

Light Alloys for. The Use of Non-Ferrous Metals in the Aeronautical Industry, D. Hanson. Engineer (Lond.), vol. 150, no. 3896, Sept. 12, 1930, pp. 291–293. Discussion of aluminum and magnesium and their alloys for aircraft construction; wrought alloys; "Y" alloys; cast aluminum alloys; approximate compositions and properties of typical aluminum casting alloys and of magnesium alloys for castings. Ninth autumn lecture to Institute of Metals, Sept. 9, 1930.

Propellers. Theory of Self Rotating Screw. Investigation of Conditions Necessary for Obtaining Maximum Braking Effect (Teoria dell'elica in autorotazione. Ricerca delle condizioni necessarie per ottenere il massimo effeto frenante), G. Serragli. Notiziario Tecnico di Aeronautica (Rome), vol. 6, no. 7, July 1930, pp. 40–53, 4 figs. Discussion of propeller action in vertical descent and at great angle of incidence.

Weight Control. Weight Saving by Structural Efficiency, A. A. Gassner. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 466–469 and 472. Analysis of factors controlling structural efficiency with particular regard to cantilever design of Fokker plane; aspect ratio, design load, wing area and maximum wing chord; selection of basic structure and best suited material; increasing, structural efficiency to save $4^1/_2$ per cent of weight of empty airplane will give $13^1/_2$ per cent increase in payload without increasing gross weight.

Weight Saving in Airplane Structures. Aviation, vol. 29, no. 4, Oct. 1930, pp. 223–226, 2 figs.

Abstract of two papers presented at National Aeronautic meeting of S.A.E., Chicago: Weight Saving by Structural Efficiency, A. A. Gassner and C. W. Hall; former discussed structural efficiency in design; choice of basic structural system best suited for aerodynamical space and wear requirements; kind of material best suited for this basic structure; use of selected materials in such way that least amount gives required strength; Hall's method of saving weight by curving gravity axis of member in anticipation of load to which it is to be subjected.

Wind-Tunnel Testing. Wind Tunnel Experiments on the Burnelli All-Wing Principle, A. Klemin. Aviation Eng., vol. 3, no. 9, Sept. 1930, pp. 22–24, 4 figs. Summary of test results on large twin-engined transport plane; curves for various coefficients of aerodynamic efficiency are given and body and wing arrangement illustrated.

AIRSHIPS

Rigid. The Development of Rigid-Airship Construction, V. C. Richmond. Engineering (Lond.), vol. 130, nos. 3374 and 3376, Sept. 12, 1930, pp. 341–344 and Sept. 26, pp. 412–414, 2 figs. Idea of what future airships may look like may be gained from trend of development described increase to twice capacity of existing vessels, and more, in lifetime of present generation can be foreseen without insuperable engineering difficulty; such ships, 1000 ft. long and of 200 ft. girth, will constitute largest moving structures in world; with present speed of 70 to 80 m.p.h., saving in time constitutes great advantage over other forms of transport. Paper read before Section G, Brit. Assn.

ALLOY STEEL

Anti-Corrosive. Recent Progress in Steel Metallurgy (Neuere Fortschritte in der Metallurgie des Stahles), E. H. Schulz. Zeit. fuer Angewandte Chemie (Berlin), vol. 43, no. 28, July 12, 1930, pp. 632–634, 3 figs. Notes on improvement of steel by addition of copper and comparison with ordinary steel; other anti-corrosive steels, such as Armco iron, molybdenum and vanadium steel, and their properties.

Castings, Heat Treatment of. Trends in Heat Treatment of Alloy Steel Castings, A. W. Lorenz. Iron Age, vol. 126, no. 11, Sept. 11, 1930, pp. 693–695 and 755–756, 3 figs. Brief review of manufacturing methods and equipment; properties and application of principal alloy castings.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.
Bearing Metals. See BEARING METALS.
Copper. See COPPER ALLOYS.
Light. See AIRPLANES, Light Alloys.

ALUMINUM ALLOYS

Aluminum-Iron-Silicon. Constituents of Aluminum-Iron-Silicon, W. L. Fink and K. R. Van Horn. Am. Inst. Min. and Met. Engrs—Tech. Pub., no. 351, for mtg. Sept. 1930, 11 pp., 6 figs. Result of uncompleted study of constituents of aluminum-iron-silicon system; methods employed; preparation of specimens; X-ray methods; silicon; aluminum-iron compound found in aluminum-iron alloys up to 40 per cent iron; alpha and beta iron-silicon compounds; table of interplanar spacings. Bibliography.

Aluminum-Silicon-Magnesium. Aluminum-silicon-magnesium Casting Alloys, R. S. Archer and L. W. Kempf. A. I. M. E.—Tech. Pub., no. 352, Sept. 1930, 34 pp., 19 figs. Object of work described was development of alloys and heat treatment for production of sand castings and permanent-mold castings having advantages of binary aluminum-silicon alloys; constitution of alloys; theory of heat treatment; previous work on castings; experimental methods and materials used; effect of pouring temperature; corrosion resistance; machinability; some properties of castings. Bibliography.

Die-Cast Castings. Pressure Die-Cast Aluminum Alloy Test-Pieces, J. D. Grogan. Inst. of Metals—Advance Paper (Lond.), no. 530, for mtg. Sept. 9–12, 1930, 18 pp., 14 figs.; see also Engineering (Lond.), vol. 130, no. 3374, Sept. 12, 1930, pp. 345–347, and (discussion) pp. 334–335, 11 figs. Investigation of mechanical strength of aluminum alloys when pressure cast in form of small tensile test pieces; behavior of selected alloys when subjected to attack of molten aluminum alloy and method of entry of metal under pressure into simple cylindrical mold; results indicate that, if certain technical difficulties can be overcome, process will yield products of excellent mechanical properties.

Properties. Modulus of Elasticity of Aluminum Alloys, R. I. Templin and D. A. Paul. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 366, Sept. 1930, 9 pp., 5 figs. Modulus of elasticity as affected by alloying elements commonly used; results of tensile tests made on aluminum-magnesium series of alloys, both heat-treated and not heat-treated, on number of alloys of aluminum-magnesium type containing different percentages of various alloying elements, and on number of aluminum alloys containing appreciable amounts of alloying elements; apparatus used; method of determining E from tensile stress-strain data.

AUTOGIROS

Theory of. The Autogiro Analyzed, W. L. Le Page. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 257–262, 9 figs. Brief history of its development and elementary theory of flight; mast upon which hub is mounted generally is set slightly to one side to correct for lack of symmetry; climbing speed is not as good as that for equivalent airplane, but angle of climb is greatly superior.

AUTOMOBILE ENGINES

Acceleration. Automobile-Engine Acceleration, C. S. Bruce. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 274–278 and (discussion) 278 and 319, 12 figs. Comparisons of fuel performance with downdraft and updraft induction-systems and with three separate carburetors connected by short pipes to three intake ports of engine; fuel volatility tests.

Cadillac—16-Cylinder. Reasons for the 16-Cylinder V-Type Cadillac Engine, W. R. Strickland. Soc. Automotive Engrs.—Jl., vol. 27, no. 2, Aug. 1930, pp. 154–159 and (discussion) 159–160, 11 figs. General layout and engineering considerations responsible for adoption of design; charts show greater smoothness of operation of V-16 compared with 6- and 8-cylinder engines; advantages of using smaller bore and piston displacement per cylinder are pointed out.

Design. Thermal Expansion in Automotive Engine Design, F. Jardine. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 311–317 and (discussion) 317–319, 5 figs. Discussion of methods to eliminate difficulties due to different rates of thermal expansion of aluminum and iron; aluminum connecting rods with steel caps; keeping cylinder-head studs tight; fit of piston pins in aluminum.

Progress in Automobile-Engine Design (Einige Fortschritte beim Automobilmotorenbau), Hillen. Allgemeine Automobil-Zeitung (Berlin), vol. 31, no. 35, Aug. 30, 1930, pp. 11–15, 7 figs. General discussion of methods for reducing wear and tear of various units of automobile and engine; piston-ring manufacture, surface treatment of working parts, oil coolers and separators for breaking in of engines at Stoewer plant.

Diesel. See DIESEL ENGINES, Automotive.

AUTOMOBILES

Brakes. Fundamentals of Brake Design, A. W. Frehse. Soc. Automobile Engrs.—Jl., vol. 27, no. 2, Aug. 1930, pp. 170–177, and (discussion) p. 178, 11 figs. Review of mathematical principles and discussion of thermal and dynamic effects and their influence on parts constituting brake; falacies of simple shoebrake and method for overcoming them; mechanical brake hook-up systems; wear of brake lining and acceleration curve.

Clutches. Automatic Clutch With Electrical Control (Kupplungsautomat mit elektrischer Steuerung), P. Friedmann. Allgemeine Automobile-Zeitung (Berlin), vol. 31, no. 37, Sept. 13, 1930, pp. 9–11, 3 figs. Clutch is operated by vacuum servo mechanism which in turn is controlled by opening and closing of electric circuits by switches connected to gear lever and accelerator peddle; sketch illustrates functioning of device which can be attached to any car at cost of approximately $20.

New Automatic Clutch. Motor (Lond.), vol. 58, no. 1497, Sept. 2, 1930, pp. 189–190, 5 figs. Description of free wheel and automatic mechanism controlling clutch patented by E. Gillett, Reduction Gears, Ltd.; sketches show principal details.

Malleable-Iron Parts. Malleable Iron Castings in Automotive Design, H. A. Schwartz. Product Eng., vol. 1, no. 9, Sept. 1930, pp. 410–411, 6 figs. Discussion of advantages of use of casting in automobile manufacture; economics resulting from use of malleable iron coatings.

Riding Qualities. Automotive Research Preliminary Study of Riding Qualities, G. C. Brandenburg and A. Swope. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 355–359, 12 figs. Investigation of subject of feelings involved in riding qualities of automobile; motion sound, sight, smell, spatial relations, esthetics; skidding; speed on open road; acceleration.

Streamline. Burney Streamline Car. Motor (Lond.), vol. 58, no. 1499, Sept. 16, 1930, pp. 277–281, 10 figs.; see also Autocar (Lond)., vol. 65, no. 1820, Sept. 19, 1930, pp. 541–547, 5 figs., and Automotive Industries, vol. 63, no. 13, Sept. 27, 1930, pp. 450–451, 4 figs. Design and performance of ultra-streamlined car with engine compartment in rear; engine has bore and stroke of 56 by 108 mm., 2.956 cc., and develops 80 hp. at 3600 r.p.m. giving car speed of 80 m.p.h.; sketches show structural details.

Wheels. Mass Production of Disk and Wire Type Auto Wheels, A. H. Allen. Steel, vol. 87, no. 12, Sept. 18, 1930, pp. 47–52, 11 figs. Description of manufacturing methods and equipment at plant of Budd Co.; daily capacity is 25,000 truck disk wheels, 20,000 disk wheels and 35,000 wire wheels for passenger cars.

AUTOMOTIVE FUELS

Gas Oil. Utilization of Gas Oil in Motor Trucks (De l'utilisation du gas-oil dans les caminons automobiles), A. Grebel. Chaleur et Industrie (Paris), vol. 11, nos. 122 and 123, June 1930, pp. 277–285 and July, pp. 333–343, 5 figs. Review of experiences with motor trucks using gas oil in Diesel engines and carburetor engines with special equipment; data on producer-gas motor trucks are also given; investigations are made regarding fuel economy, cost of equipment, operating conditions, and exhaust gas-composition.

Properties. Suitability of Fuels for Modern Internal-Combustion Engine (Les carburants appropriés aux moteurs à explosion modernes), A. Grebel. Chimie et Industrie (Paris), vol. 23, nos. 4, 5 and 6, Apr. 1930, pp. 825–833, May, pp. 1082, 1091, and June, pp. 1353–1358, 15 figs. Survey of properties, chemical composition, and combustion characteristics of gasoline and oil fuels for all kinds of internal-combustion engines; control of detonation by compounding and addition of various substances.

Testing. Latent Heat of Vaporization of Fuels and Measuring Method (Die Verdampfungswaerme der Kraftstoffe und eine Methode zu ihrer Bestimmung), Wawrziniok. Automobiltechnische Zeit. (Berlin), vol. 33, nos. 25 and 26, Sept. 10, 1930, pp. 618–620 and Sept. 20, pp. 644–646, 3 figs. Effect of heat of vaporization on engine performance. New principle and apparatus for determining its value for non-homogeneous liquids give accurate checks; tables give data on alcohol-benzol mixtures.

Volatile. Volatile Liquid Fuels, H. C. Dickinson. Petroleum World (Lond.), vol. 26, nos. 358 and 359, July 1930, pp. 248–254 and Aug., pp. 273–274. July: Fuel volatility and economy; dilution of crankcase oil; engine starting; engine acceleration; vapor lock; knock characteristics of fuels; gasoline specifications. Aug.: Potential sources of motor fuel. Paper read at World Power Conference, Berlin.

[See also AIRPLANES, Fuels.]

B

BEARING METALS

Bronze. Bearing Bronzes With Additions of Zinc, Phosphorus, Nickel, and Antimony. U. S. Bur. of Standards—Jl. of Research, vol. 5, no. 2, Aug. 1930, pp., 349–364, 16 figs. Study was made of copper-tin-lead-bearing bronzes with and without additions of zinc, phosphorus, nickel, and antimony; test made included wear resistance, resistance to impact, Brinell hardness, and resistance to repeated pounding at several temperatures.

BOILERS

Design. Developments in Boiler Design. World Power (Lond.), vol. 14, no. 81, Sept. 1930, pp. 257–259, 1 fig. Design of steam-raising boilers has undergone various developments and modifications during recent years in order to meet improvements in methods of combustion, introduction of new systems of combustion, and notably higher steam pressures which have become common; illustrated description of design features incorporated in Chalk boiler.

Progress in Design of Small and Medium-Sized Boilers (Fortschritte im Kesselbau fuer kleine und mittlere Kessel), R. Schulze. Waerme (Berlin), vol. 53, no. 39, Sept. 27, 1930, pp. 727–729, 3 figs. Based on brief statistical data, it is shown that small and medium-sized boilers predominate in industrial plants; test results on new design, constructed by Vereinigte Kesselwerke from design by Huygens, showed good efficiency and high output; it has advantages of old fire-tube boilers, but requires no masonry, thus greatly cheapening price of installation.

Firing. Influence of Stoker Speed on Furnace Processes (Der Einfluss der Rostgeschwindigkeit auf die Vorgaenge in der Feuerung), W. Gumz.

Feuerungstechnik (Leipzig), vol. 18, no. 17–18, Sept. 15, 1930, pp. 171–173, 3 figs. Influence of stoker speed on ignition, coking, temperatures of fuel bed, and combustion; conclusions for construction of mechanical grates, for use of air preheating and for describing firing tests.

Furnaces. Modern Grate Furnaces (Neuere Rostfeuerungen—Fortschritte und Versuchsergebnisse), R. Schulze. Waerme (Berlin), vol. 53, no. 36, Sept. 6, 1930, pp. 665–669, 6 figs. Notes on progress and experimental results; by comparison of some entirely new boiler installations with others 4 to 6 years old, extent of improvement in past few years is shown.

Relations Between Furnace, Furnace Temperature, Combustion Process and Efficiency (Feuerraum, Feuerraumtemperatur, Verbrennungsvorgang, Wirkungsgrad), Marcard. Waerme (Berlin), vol. 53, no. 39, Sept. 27, 1930, pp. 714–726, 26 figs. Critical study of mean furnace temperature and its influence on furnace design and combustion process; methods of determining heat volume transmitted in furnace through radiation; discussion of efficiency based on different losses; article gives examples of practical applications.

Heads. Calculation of Boiler Heads Exposed to Internal Pressure (Calcul des fonds soumis à une pression intérieure), E. Hoehn. Chaleur et Industrie (Paris), vol. 11, no. 123, July 1930, pp. 313–319, 15 figs. Discussion of test results and methods for calculating stresses in dished boiler heads.

High Pressure. Super-Pressure Boiler at Bradford Power Station. Engineer (Lond.), vol. 150, nos. 3895–3896, Sept. 5 and 12, 1930, pp. 244–246 and 279–280, 20 figs. Sept. 5: Duty of boiler is to generate normally 75,000 lb. of steam per hr. at pressure of 1100 lb. per sq. in. and temperature of 800 deg. fahr. though output of 94,000 lb. of steam per hr. can be continuously maintained; boiler is cross-drum marine type; furnace is entirely water cooled, tubes connected with boiler system abstracting heat from side walls, back and arch with its front wall. Sept. 12: Stoker is of Babcock and Wilcox's latest compartment type; it has working length of 18 ft. and is 21 ft. 5 in. wide, thus having total working surface of practically 386 sq. ft.; it is largest single stoker in service in Great Britain; feature of grate is absence of any stress in links themselves; stoker is equally suitable for balanced or simple induced draft, change from one to other being effected in few moments.

Lancashire. The "Super-Lancashire" Boiler. Iron and Coal Trades Rev. (Lond.), vol. 121, no. 3260, Aug. 22, 1930, pp. 258–259, 2 figs. Note on boiler developed and tested at plant of manufacturer at Dukinfield, England; complete unit comprises boiler 20 ft. long by 8 ft. 6 in. diam., superheater, air heaters, induced-draft fan direct-coupled to small high-speed engine, and forced-draft fan direct-coupled to 5-b.hp. motor; test data.

Riveting. A New System of Riveting. Engineer (Lond.), vol. 150, no. 3896, Sept. 12, 1930, pp. 276–277, 7 figs. Attempt to avoid difficulties of scale, and insufficient upsetting of shank at head end, resulted in introduction of Schuch system of riveting; head of rivet is conical before closing to allow scale to escape readily, and to promote swelling of upper end of shank; Skoda Works, Czechoslovakia, have eliminated all previous manufacture of rivets and use plain lengths of rivet iron cropped from bar; process facilitates workmanship of highest class, while minimizing production cost; Skoda works employ pin riveting for all locomotive boilers.

Vibrations. Observations on Pulsating Boilers (Beobachtungen an brummenden Dampfkesseln), F. Kaiser. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 34, nos. 16 and 17, Aug. 31, 1930, pp. 223–225 and Sept. 15, pp. 234–236, 2 figs. Number of examples are cited to show to what extent pulsation can be attributed to certain factors, such as nature of combustion, design of flues, and cleanliness of boilers.

Wood-Waste-Fired. Design of Furnaces and Fuel Feeders for Burning Refuse, M. A. Hofft. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 16–17, 1930, 9 pp., 10 figs. Recent development in design of furnace for burning dry wood refuse in suspension; factors influencing design of wood-burning furnaces in industrial plants; development of inclined-grate furnaces for burning refuse fuels; development of automatically controlled dry wood-refuse feeders and storage bins.

BRAZING

Electric-Resistance Method. Brazing by Resistance Method, W. C. Reed, M. Unger, and G. E. Gifford. Gen. Elec. Rev., vol. 33, no. 10, Oct. 1930, pp. 568–570, 7 figs. Many metals such as copper, nickel, silver, steel, and their alloys can be brazed electrically; this type of brazing has been perfected in Pittsfield Works Laboratory of General Electric Co. and used extensively in production work for two years; equipment required; handling capacity; preparation of joints; technique employed in brazing operation.

Electric Resistance Brazing Affords Durable Joints, G. E. Gifford. Steel, vol. 87, no. 11, Sept. 11, 1930, pp. 59–60, 3 figs. Description of methods and equipment developed by General Electric Co., Schenectady, N. Y.; difference between pressure brazing and resistance brazing is explained and data are given on fluxes and silver alloys.

C

CAMS

Milling. Milling Cams Correctly, A. L. DeLeeuw. Am. Mach., vol. 73, no. 13, Sept. 25, 1930, pp. 503–505, 5 figs. Rapid wear in barrel cams is avoided by special machine which produces theoretically correct grooves, built by American Machine & Foundry Co.; master cam engages fixed roller to actuate cam blank during cut; data on feeds, speeds, and output.

CARBON DIOXIDE RECORDERS

Duscom Type. A New Combustion Recorder. Eng. and Boiler House Rev. (Lond.), vol. 44, no. 3, Sept. 1930, pp. 182 and 184, 2 figs. Illustrated description of operation of Duscom carbon-dioxide and carbon-monoxide recorder; record chart showing carbon-dioxide and carbon-monoxide readings.

CARS, PASSENGER

Air Conditioning. Air Conditioning for Railway Passenger Cars, J. H. Davis. Baltimore Engr., vol. 5, no. 5, Aug. 1930, pp. 4–11 and 20, 12 figs. Satisfactory solution of problem has been retarded because of inadequate supply of electric energy available on moving train, as well as space and weight limitations for required equipment applicable to individual cars; recent advances in electric power generation on moving train and development in air-conditioning equipment offer promise of overcoming these limitations; system as in use on Baltimore & Ohio railroad is described.

CASE HARDENING

Carburizing. Normal and Abnormal Steel (Normaler und anormaler Stahl), E. Houdremont and H. Mueller. Stahl und Eisen (Duesseldorf), vol. 50, no. 38, Sept. 18, 1930, pp. 1321–1327, 13 figs. Report of Subcommittee on Case Carburizing Testing of Materials Committee of Verein deutscher Eisenhuettenleute; metallographic characteristics of normal and abnormal steels; physicochemical methods of analysis; influence of treatment on behavior of steel; metallurgical processes and their relations to observed phenomena. Article includes bibliography.

Cyanide Bath. Structure of Steel Immersed in Cyanide Bath. (Gefuege un Zyanidsalzbad eingesetzten Stahles), W. Henninger and H. Jurich. Stahl und Eisen (Duesseldorf), vol. 50, no. 38, Sept. 18, 1930, pp. 1334–1335, 4 figs. By etching with hot concentrated sodium-picrate solution, it is possible to detect eutectoid and needles in structure of low-carbon case-hardened steel after 5-hr. treatment in cyanide-hardening flux and subsequent slow quenching; carbon and nitrogen absorption in subsequent slow quenching; carbon and nitrogen absorption incyanide flux is shown in curve.

CAST IRON

Electric-Furnace Melting. The Manufacture of Cast Iron in the Electric Furnace, W. Lister. Foundry Trade Jl. (London), vol. 43, no. 733, Sept. 4, 1930, pp. 165 and 167. Outline of advantages over cupola such as reduction of sulphur content, complete solution of carbon, and uniform structure; neutral higher temperature; data on melting procedure and duplexing method are given; table shows analysis of cupola-melted irons before and after treatment in electric furnace.

High-Test. Progress in Grey Iron Castings, H. Bornstein. Metal Progress, vol. 18, no. 4, Oct. 1930, pp. 43–46, 6 figs. Physical properties and composition of high-strength cast iron, alloy cast iron, and heat treatment of gray-iron castings; microphotographs illustrate various structures; heating temperature and machinability.

CASTINGS

Centrifugal. Large Centrifugal Castings Made at Navy Yard, J. F. Crowell. Iron Age, vol. 126, no. 15, Oct. 9, 1930, pp. 994–996, and 1047, 3 figs. Methods and equipment for making centrifugal castings, including pipe for water, gas and oil mains; cylinder liners for engines and pumps; babbitt bearing surfaces of large bearing brasses, and sleeves for tail shaftings: sketch shows plan of elevation of centrifugal machine for use in making castings 14 ft. long and 28 in. diam.

Cleaning. Cleaning of Castings by Means of Water Jet (Kritische Betrachtungen ueber das Putzen von Gusstuecken mittels Wasserstrahl), A. Rodehueser. Giesserei (Duesseldorf), vol. 17, nos. 36, 37, and 38, Sept. 5, 1930, pp. 882–884 and Sept. 12, pp. 896–903, and Sept. 19, pp. 926–930, 14 figs. Action of water jet; design of wet cleaning plant and experimental arrangement; volume of water required per second; influence of pipe friction; maximum kinetic energy with given nozzle diameter; influence of length of pipe line; back pressure; distribution of wages and water costs in relation to nozzle diameter; relations between physical and economic optimum nozzle.

CHROMIUM-VANADIUM STEEL

Properties and Uses. Vanadium Additions Improve Steel, N. Petinot. Steel, vol. 87, nos. 8, 9, 10, Aug. 21, 1930, pp. 43–45 and 48, Aug. 28 1930, pp. 47–49 and Sept. 4, pp. 56–57, 60, 7 figs. Development of vanadium-containing steels in United States, properties and present application in major industries; effects of vanadium upon steels; properties of vanadium steels and discussion of commercial applications; use of vanadium as process element. Paper read before Sixth International Congress of Min., Met. and Applied Geology in Liége, Belgium, June 22–28, 1930.

CLUTCHES

Jaw. Design and Production of Jaw Clutches With Sloping Teeth (Nochmals einfache Konstruktion und Herstellung von Klauen-Kupplungen mit schraegen Zaehnen), R. Matthes. Werkstattstechnik (Berlin), vol. 24, no. 17, Sept. 1, 1930, pp. 472–473, 6 figs. Outline of calculating method for jaw clutch with arbitrary number of teeth which can be cut in one milling operation; practical examples are given.

COMPRESSED AIR RECEIVERS

Explosions, Prevention of. The Prevention of Air-Receiver Explosions, E. Ingham. Mech. World (Lond.), vol. 88, no. 2278. Aug. 29, 1930, pp. 203–204, 1 fig. Air receiver's strength to resist any required pressure is easily determined, and there is little reason why possibility of explosion should not be almost entirely eliminated; safe type of air receiver is cylindrical mild-steel vessel with butt-riveted joints for longitudinal seams, lap-riveted joints for longitudinal seams, lap-riveted joints for circumferential seams, and with outwardly cambered endplates.

CONTAINERS

Shipment. Selecting the Right Container for Your Shipments, J. B. Frear. Purchasing Agent, vol. 19, no. 10, Oct. 1930, pp. 1069–1074, 16 figs. Advantages and results of drum, laboratory, shipping and compression tests in determining design, type, weight, packing, and general suitability of shipping containers.

CONVEYORS

Cargo Handling. Floating Elevator-Conveyor of 450 Cu. M. (590 cu. yd.) per Hour Capacity, G. Garbotz. Eng. Progress (Berlin), vol. 11, no. 9, Sept. 1930, pp. 236–240, 9 figs. Floating elevator conveyor supplied to Port Authorities of Rouen is described; machine has capacity of 450 cu. m. (590 cu. yd.) per hour and transporting and flushing range of 45 and 55 m. (150 and 180 ft.), respectively; construction and arrangement of component parts, hulls, slewable conveying bridge, bucket ladder, engine and boiler plant are discussed in detail.

Cement Plants. Mechanical Conveying in Cement Manufacture. Mech. Handling (Lond.), vol. 17, no. 10, Oct. 1930, pp. 335–338, 3 figs. Various mechanical-handling processes involved in manufacture of cement, and conveying appliances employed.

Chemical Plants. Longer Life for Conveyors, F. Wehle. Chem. Markets, vol. 27, no. 3, Sept. 1930, pp. 265, 267, and 269, 6 figs. Good conveying practice depends on proper thought in original design of equipment and careful attention to proper maintenance practice after it has been installed.

Redler Type. A New Conveyor Principle, G. F. Zimmer. Mech. Handling (Lond.), vol. 17, no. 10, Oct. 1930, pp. 317–319, 5 figs. Redler system of conveying based on principle of conveyor which carried continuous mass upon series of narrow strips of chain links in bottom of trough.

Rubber-Coated. Rubber-Coated Conveyors

and Containers, F. Grove-Palmer. Mech. Handling (Lond.), vol. 18, no. 9, Sept. 1930, pp. 305-306. Properly prepared rubber coatings can lengthen life of many steel and other metal conveyors; with certain important exceptions, rubber can be used for almost any type of goods either loose or packed and saving in wear and tear may be considerable.

COPPER ALLOYS

Copper-Silicon-Zinc. A New Silicon-Zinc-Copper Alloy, E. Vaders. Foundry Trade Jl. (Lond.), vol. 43, no. 735, Sept. 18, 1930, pp. 202-204, 5 figs. Composition and physical properties of various silicon-zinc-copper alloys; diagram gives ternary system silicon-zinc-copper, showing solubility curve of silicon; cooling curves of silicon-zinc-copper alloys; curves showing dependence of tensile strength elongation and hardness of silicon content; notes on foundry practice. Abstract of paper read before Inst. Metals, previously indexed from Advance Paper, no. 544.

Heat Conductivity. Thermal Conductivity of Copper Alloys—Copper-tin Alloys—Copper-phosphorus Alloys, C. S. Smith. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 360, Sept. 1930, p. 11, 4 figs. Continuation of Tech. Pub. no. 291, previously indexed; thermal conductivity of copper is rapidly reduced by addition of tin until with 10.41 per cent tin it is only 0.121 cal. per sq. cm. per sec. per deg. cent. at 20 deg. cent.; phosphorus is 10 times as powerful as tin; electrical conductivity decreases more rapidly on alloying than does the thermal conductivity, and the Wiedemann-Franz-Lorenz ratio increases rapidly at the beginning, but beyond 2.0 per cent tin or 0.15 per cent phosphorus remains almost constant.

Heat Treatment. Shaping and Annealing Treatment of Copper and Copper-Zinc Alloys, Mendl. Metal Industry (Lond.), vol. 37, no. 10, Sept. 5, 1930, pp. 217-220, 1 fig. Hot and cold deformation, annealing and impurities of copper; equilibrium diagram and stretching stresses of copper alloys. Translated from Metallwirtschaft, Mar. 21, 1930.

P. M. G. Metal. A Copper-Alloy Without Tin Having Unique Properties. Elec. Mfg., vol. 5, no. 3, Mar. 1930, p. 76, 1 fig. P. M. G. metal, developed in Vickers-Armstrongs, Ltd., Naval Construction Works, Barrow-in-Furness, England, is substitute for tin-bearing bronzes and gun metal that is easily cast or forged, is ductile and can be extruded, making it particularly adaptable for many applications in electrical industry.

COUPLINGS

Flexible. Selecting and Installing Flexible Couplings, F. A. Annett. Power, vol. 72, no. 14, Sept. 30, 1930, pp. 534-537, 8 figs. Most troubles experienced with flexible couplings can be eliminated by selecting right size and type for job, and by giving them reasonable amount of care after they have been properly installed; service factors for flexible couplings.

CRANES

Traveling. Large Portal Gantry With Raisable Jib Arm of Compagnie Rouennaise de déchargement (Le grand portique à bec relevable de la Compagnie Rouennaise de déchargement), Piernet and Tripard. Revue d'Electricité et de Mécanique (Paris), no. 12, July-Aug. 1930, pp. 31-39, 27 figs. Description, detailed design drawing and test results of 500-volt d. c. operated equipment; total length of portal is 138.55 m.; height measured over rails 61.5 m.; lifting power 12 Kg. tons at 1.20 m. lifting and 2.5 m. traveling speed.

CUTTING METALS

Economical Methods. Need for Economical Cutting Methods (Ueber die Notwendigkeit wirtschaftlicher Zerspanungsarbeit), F. Theimer. Maschinenbau (Berlin), vol. 9, no. 18, Sept. 18, 1930, pp. 598-600, 5 figs. Mathematical investigation of losses and loads under various operating conditions of machine tools; diagrams illustrate speed, feed, and forces with different metals; effect of load on efficiency.

CUTTING TOOLS

Tungsten Carbide. Cutting Tests With Cemented Tungsten Carbide Lathe Tools, T. G. Digges. U. S. Bur. of Standards—Jl. of Research, vol. 5, no. 2, Aug. 1930, pp. 365-383, 12 figs. Investigation was made for purpose of developing method of testing cemented tungsten-carbide lathe tools under heavy duty and to extend to new cutting material some of laws originally developed by Taylor and his associates for cutting with carbon and high-speed steel tools; relations were determined between speed, feed, depth of cut, and tool life for selected form and size of tool; results are presented in both graphic and tabular forms.

D

DIES

Forging. Use of Special Steels for Forging Dies (Die Verwendung von Sonderstaehlen fuer die Anfertigung von Pressgesenken), V. Fabian. Maschinenbau (Berlin), vol. 9, no. 17, Sept. 4, 1930, pp. 582-583, 6 figs. Discussion of experience with special steel of uniform hardness which increases life of dies from 5 to 40 times; data on composition and heat treatment are given.

Forming and Bending. Dies for Bulldozing and Upsetting, G. A. Smart. Heat Treating and Forging, vol. 16, no. 9, Sept. 1930, pp. 1147-1151, 15 figs. Description and sketches of various types of bulldozer and upsetter dies; die holders; adjustable back stop; adjustable bending dies; angle-iron bending dies; channel-iron bending dies; progressive bending dies (inserts, etc.); combination bending dies; piercing dies; dies used in conjunction with drop-hammer operations; selection of steel; one- two- and three-pass dies, showing all essential points; piercing dies for gears, bushings, etc.

DIESEL-ELECTRIC POWER PLANTS

Costs. Low Diesel Operating Costs, H. J. Achee. Power Plant Eng., vol. 34, no. 19, Oct. 1, 1930, pp. 1100-1101, 3 figs. Seven years operation with Diesel power at Woodward, Oklahoma, demonstrates economy of investment; operating costs with old steam plant; cost summary; chart showing varying cost and operating data for 7-yr. period.

DIESEL ENGINES

Automotive. Automotive Diesel Engines, C. G. A. Rosen. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 459-461. Requirements of satisfactory performance and weak points of principal designs with regard to suitability of fuels, maintenance cost, fuel economy, reliability over long periods, easy start and control, air injection and solid injection.

Diesel Engines for Automobiles, C. L. Cummins. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 285-289 and (discussion) 290-294, 7 figs. Experience with large sedan and roadster in which original eight-cylinder engine had been replaced by four-cylinder Diesel engine; description of metering, injection and combustion processes of Cummins engine, which are distinguished principally by separation of metering and injection operations so that former is done at low pressure.

Small Diesel Engines, H. D. Hill. Soc. Automotive Engrs.—Jl., vol. 27, no. 3, Sept. 1930, pp. 282-284 and 351 and (discussion) 290-294, 8 figs. Outline of difference in method of procedure necessary in developing large and small Diesel engines; ante-chamber fuel system used in Hill engine; recently developed automotive-type engine is described.

Flywheel Design. Simplified Calculation of Diesel Alternator Flywheels for Parallel Operation, T. Schou. Diesel Power, vol. 8, no. 9. Sept. 1930, pp. 474-479, 17 figs. Calculation of flywheels for Diesel-engine-driven alternators, when correctly carried out on basis of fundamental differential equation given by Doherty and Franklin, is laborious and difficult; results worked out for 16 of commonest engine arrangements; with aid of various factors inertia of flywheel for any other type of engine belonging to group of 16 may be easily arrived at by use of simple multiplication formula; specific examples are illustrated.

E

ELECTRIC FURNACES

High-Frequency. High Frequency Steel Furnaces, D. F. Campbell. Engineering (Lond.), vol. 130, no. 3376, Sept. 26, 1930, pp. 409-411, 5 figs. Survey of present status of ironless induction furnace shows that its field of utility is much wider than is generally supposed; ironless induction furnaces of Ajax-Northrup type of hourly output of 20 to 25 cwt. have been operated since July 1929; at present largest units are furnaces of 20 to 25 cwt. capacity per heat, giving output of 20 tons per day, but design of furnaces of 3 to 5 tons presents no technical difficulties; steel-making operations to which these furnaces have been applied. Paper read before Iron and Steel Inst. at Prague, Sept. 16, 1930.

ELECTRIC WELDING, ARC

Shrinkage Stresses. Shrinkage Stresses in Arc Welding (Schrumpfspannungen und deren Beachtung beim Lichtbogenschweissen), Lottmann. V.D.I. Zeit. (Berlin), vol. 74, no. 38, Sept. 20, 1930, pp. 1340-1345, 19 figs. Causes and conditions leading to shrinkage; practical shrinking coefficients; shrinkage stresses in case of complete and incomplete fixedness of welds; effect of peening; rules for minimizing shrinkage stresses.

Testing. Develops New Technique in Electric Arc Welding, J. D. Knox. Steel, vol. 87, no. 15, Oct. 9, 1930, pp. 62 and 65, 3 figs. Results of tests made with new electrode developed by Babcock & Wilcox Co.; data on composition of electrode material and physical properties of arc weld; maximum of 74,500 lb. per sq. in. ultimate tensile strength.

ELEVATORS

Bucket. Design of Bucket Elevators, N. Tate. Mech. World (Lond.), vol. 88, no. 2278, Aug. 29, 1930, pp. 195-198, 4 figs. Chain and bucket is better than belt and bucket when material handled is higher in temperature than 400 deg. fahr., as heat injures rubber covering and duck fabric of which belt is made; capacity of continuous bucket elevators handling coal or crushed stone; vertical and inclined elevators.

Electric, Design of. Power Calculations for Elevators by the Method of Probabilities, B. Jones. Gen. Elec. Rev., vol. 33, no. 10, Oct. 1930, pp. 545-555, 12 figs. Theory of probabilities tempered by engineering experience and common sense, has resulted in basis for selection of elevator equipment that fulfills service requirements and yet is no larger than actually necessary; notes on occupancy factors affecting elevator service; elevator duty cycle; current imput; average and root mean square imput for single motor; operating factor values; probability data; example of actual case.

F

FLOW OF FLUIDS

Pipes. Modern Measurements of Pressure Loss in Pipes and Law of Surface Friction With Large Reynolds Coefficients (Die neueren Messungen des Druckverlustes in Rohren und das Gesetz der Oberflaechenreibung bei grossen Reynoldsschen Zahlen), H. Lerbs. Werft Reederei Hafen (Berlin), vol. 11, no. 17, Sept. 7, 1930, pp. 365-367, 6 figs. Nikuradse's new measurements of pressure loss in pipe are used to develop law of surface friction based on generalization of Karman's calculation of law of Blasius; brief contribution by F. Eisner is appended.

FORGINGS, STEEL

Heat Treatment. Forging and Heat Treating Departments of the Pennsylvania Railroad, C. I. Snowberger and E. Hoenstine. Heat Treating and Forging, vol. 16, no. 9, Sept. 1930, pp. 1140-1144 and 1155, 8 figs. Description of Forging and Heat Treating Department of Pennsylvania Railroad at Altoona, Pa.; sketches show arrangement of furnaces and location of hammers, presses, and other equipment.

FOUNDRY EQUIPMENT

Sand Blasts. Sand Blasts According to Gravity-Pressure System (Sandstrahlgeblaese nach dem Schwerkraft-Drucksystem), W. Kaempfer. Giesserei (Dusseldorf), vol. 17, no. 38, Sept. 19, 1930, pp. 931-933, 4 figs. Advantages and disadvantages of gravity and pressure systems; description of new design which combines both systems avoiding their disadvantages; application to cleaning of iron and steel castings.

FURNACES

Heat-Treating, Gases. Influence of Furnace Atmospheres on Correct Heat Treatment, E. W. Esslinger. Metal Progress, vol. 18, no. 4, Oct. 1930, pp. 60-67, 5 figs. Effect of carbon dioxide, carbon monoxide, free oxygen, water vapor, and nitrogen upon surface of steel: ideal atmosphere for annealing, drawing, box carburization, and preheating in neutral atmosphere, or one which contains trace of free oxygen; scaling effects of gases.

Heat-Treating, Rotary. Rotary Hearth Furnace for Heat Treating, R. E. Barker. Heat Treating and Forging, vol. 16, no. 9, Sept. 1930, pp. 1189-1190, 1 fig. Furnace for annealing, case hardening, etc. for coal firing; performance data and sketches are given.

Laboratory, High-Temperature. New High-Temperature Based on Principle of Surface Combustion (Ein neuer Verbrennungsofen fuer hohe Temperaturen nach dem Prinzip der Oberflaechenverbrennung), E. Ryschkewitsch.

Feuerungstechnik (Leipzig), vol. 18, no. 17/18, Sept. 15, 1930, pp. 173–176, 2 figs. Nature of surface combustion; technical disadvantages of former furnace designs; description of new system, so-called Roessler furnace, of employing surface combustion; eliminating technical shortcomings; attempt is made to explain catalytic surface action on combustion process; in furnace described temperature of 2100 deg. cent. can be obtained with coal gas of only 4200 calories per cu. m.

G

GAGES

Reed Indicator. Reed Gages Guarantee Close Tolerances Under Shop Conditions, C. F. Dreyer. Factory and Indus. Mgmt., vol. 80 no. 4, Oct. 1930, pp. 722–724, 10 figs. Improvement in indicator gage which will permit its use in control of product tolerances defined in ten-thousandths of inch; limitations of fixed gages and of usual forms of indicators; construction of fixed gages and of improved indicator gage; advantages shown in number of successful applications.

GAS ENGINES

Combustion in. Influence of Nitrogen in Air Supply on Combustion in Gas Engines, R. Matthews. Power, vol. 72, no. 14, Sept. 30, 1930, pp. 548–549, 1 fig. Recent experiments with gases in bombs show conclusively that nitrogen under some conditions is not neutral constituent during combustion; effects of nitrogen, oxygen and excess carbon monoxide upon engine combustion, with variation in pressure rise with time; rapidity of combustion.

GAS PRODUCERS

Types. Producer Gas Practice From the Point of View of the Carbonizing Industries, N. E. Rambush and F. S. Townend. Gas. Jl. (Lond.), vol. 191, no. 3508, Aug. 13, 1930, pp. 369–370. Two types of producers described are brick-built static type and mechanical-grate central producer; brief description of several installations; trend of development in mechanical producers. From paper read before World Power Conference, Berlin.

The Gas Producer—Continuous Producer, J. W. Romig. Am. Gas Jl., vol. 133, nos. 2 and 3, Aug. 1930, pp. 47–48 and Sept., pp. 44–45, 3 figs. Little information available as to actual temperatures in various zones of industrial gas producers; knowledge of reactions existing in distillation zone rather vague; heats of reactions in gas producer; producer gas constituents and percentages for bituminous coal gas; products of combustion of combustible in producer gas.

GASES

Specific Heats at High Pressures. Specific Heats of Gases at High Pressures, B. H. Mackey and N. W. Krase. Indus. and Eng. Chem., vol. 22, no. 10, Oct. 1930, pp. 1060–1062, 2 figs. Methods of measurement and calculation of specific heats of gases as function of temperature and pressure have been developed, and results for nitrogen up to 150 deg. cent. and 700 atmos. are presented.

GASOLINE ENGINES

Compression Ratio. In Influence of Turbulence Upon Highest Useful Compression Ration in Petrol Engines, T. F. Hurley and R. Cook. Engineering (Lond.), vol. 130, no. 3373, Sept. 5, 1930, pp. 290–293, 10 figs. Account of work being carried out at Fuel Research Station; engine used is E.5 Ricardo variable-compression engine, of $2^7/_8$ in. bore by $3^1/_4$ in. stroke; it was found that optimum spark advance at given compression ration with indiscriminate turbulence was, generally speaking, larger than that necessary with rotational turbulence; theory is advanced which affords explanation of most of observed phenomena, including that in connection with spark advance. Paper read before Brit. Assn., Sept. 4, 1930.

GEARS

Heat Treatment. Lathe Transmission Gears, D. M. Gurney. Metal Progress, vol. 18, no. 3, Sept. 1930 pp. 68–70, 3 figs. Brief outline of production hardening methods used by Warner & Swasey Co. of Cleveland; data on annealing, normalizing, and composition of blanks; required hardness ranges from 512 to 532 Brinell.

Teeth, Strength of. Practice of Calculating Gear Tooth Strength Shown to Be Erroneous by Research Committee in Report to Semi-Annual Meeting of A.G.M.A., P. M. Heldt. Automotive Industries, vol. 63, no. 15, Oct. 11, 1930, pp. 508–511, 2 figs. Relation between increment load and pitchline velocity of gears in Lewis testing machine; load capacity of worm gears; friction and wear characteristics.

GRINDING MACHINES

Surface. Heavy Vertical-spindle Surface Grinder With Reciprocating Table, S. Weil. Eng. Progress (Berlin), vol. 11, no. 10, Oct. 1930, pp. 267–269, 3 figs. Grinder spindle of machine is driven by two 30-hp. motors running at 1450 r.p.m. and capable of transient overload of 50 per cent; motors are arranged to either side of spindle, which they drive over elastic couplings and geared reductions; segmental abrasive wheel of 4.6 ft. diameter is used; spindle head is pivotally suspended at top from two heavy pins, and held at bottom by two special screws.

H

HARDNESS TESTING

Brinell. Offers Some New Hardness Tables, T. N. Holden, Jr. Iron Age, vol. 126, no. 14, Oct. 2, 1930, p. 932. Tables give Brinell hardness number for 5-mm. ball with 750 and 250 kg. load; 10-mm. ball with 3000, 1000, and 500-kg. load; data on preparation of surfaces for Brinelling.

HOISTS

Modern Types. Modern Hoisting Machinery (Neuere Hebezeuge), R. Dub. Foerdertechnik und Frachtverkehr (Wittenberg), vol. 23, nos. 16 and 17, Aug. 1, 1930, pp. 315–320, and Aug. 15, pp. 339–342, 22 figs. Traveling crane with fixed universal rope guides, with 32 m. span and 80-hp. hoisting motor is described, also lift platform trucks and hoists with traveling crab for loading high bins; wiring diagrams.

HOT-WATER ACCUMULATORS

Displacement Type. Displacement Accumulator in Heating Systems (Verdraengungsspeicher in Heizbetrieben), Schueler. Waerme (Berlin), vol. 53, no. 36, Sept. 6, 1930, pp. 670–674, 11 figs. Heat accumulators of a district hot-water heating system in Berlin-Schoeneberg are described; details of boiler plant and accumulator installation; latter are operated as displacement accumulators, that is, they are always completely filled, in charged state with water up to 120 deg. cent., in discharged state with water of return-flow temperature; if partially charged, upper part contains water at 120 deg. and lower part water of return-flow temperature.

HYDRAULIC ACCUMULATORS

Uses. Hydraulic Accumulators Charged With Compressed Air (Hydraulische Akkumulatoren mit Druckluftbelastung), R. Sackheim. V.D.I. Zeit. (Berlin), vol. 74, no. 36, Sept. 6, 1930, pp. 1234–1236, 4 figs. Applications and advantages of hydraulic accumulators; types of construction and regulation of high-head and low-head hydraulic accumulator plants.

HYDRAULIC LABORATORIES

United States. Alden Hydraulic Laboratory—Workshop of Modern Research, F. A. Annett. Power, vol. 72, no. 11, Sept. 9, 1930, pp. 418–422, 7 figs. Adequate hydraulic laboratory facilities in United States have been generally lacking; however, much valuable hydraulic research work has been done in laboratories of manufacturers, power companies, and universities; in this work Alden Hydraulic Laboratory of Worcester Polytechnic Institute has taken preeminent part; diagram of laboratory's property is illustrated.

HYDRAULIC TURBINES

Design. Important Points in the Design and Operation of High Speed Hydraulic Turbines (Ueber einige wichtige Punkte beim Bau und beim Betrieb schnellaufender Wasserturbinen), R. Thomann. Elektrotechnik und Maschinenbau (Vienna), vol. 48, no. 39, Sept. 28, 1930, pp. 889–897, 23 figs. Design principles applying to turbines of which specific rotary speed exceeds 70, i.e., pressure turbines, propeller and Kaplan turbines.

I

ICE

Specific Heat. Specific Heats and Latent Heat of Fusion of Ice, W. H. Barnes and O. Maass. Can. Jl. Research (Ottawa), vol. 3, no. 3, Sept. 1930, pp. 205–213, 1 fig. Values for heat capacities of ice and resulting water from initial temperatures of between 0 and 78.5 deg. cent. to final temperature of plus 25.00 deg. are measured to plus 0.05 per cent or better with improved adiabatic calorimeter; specific heats of ice over temperature range; to —80 deg. are found and latent heat of fusion of ice at 0 deg. is obtained from these heat-capacity determinations. Bibliography.

INDUSTRIAL TRUCKS

Lift. Devices for Handling Awkward Heavy Articles. Engineer (Lond.), vol. 150, no. 3895, Sept. 5, 1930, p. 261, 4 figs. Details of special lifting truck developed by Transporting Machinery Co., for handling drums used for carrying heavy electric cables or wire ropes; trucks are suitable for dealing not only with rolls of paper but also with beams of cloth, etc.; further aid to rapid and easy manipulation of paper rolls and similar articles, introduced by this Company, is automatic releasing grab; specially intended for handling of such objects in conjunction with overhead cranes.

INTERNAL-COMBUSTION ENGINES

Air Filters. The Efficiency of Air Filters for Internal Combustion Engines, W. Alexander. Engineering (Lond.), vol. 130, no. 3373, Sept. 5, 1930, pp. 295–296, 2 figs. Letter to editor referring to article by W. E. Gibbs, A. Brandt, and M. L. Nathan, previously indexed from Aug. 22 issue of this journal; only centrifugal separator of which test results are given is old-fashioned cyclone; there are now applied to carburetor inlets vortical separators of through-flow type, which give movement to air much nearer to streamline motion of free or Rankine vortex than is given by cyclone; example of more modern type, called Supreme vortex separator, is illustrated.

Austria. Internal-Combustion Engines in Power Practice (Die Verbrennungsmotoren in der Energiewirtschaft), L. Richter. Elektrotechnik und Maschinenbau (Vienna), vol. 48, no. 38, Sept. 21, 1930, pp. 874–881, 4 figs. Classification of various types of engines and principal characteristics; fuel, prices, and location of operation; comparison of operating costs of electric motors, Diesel engines, and gas engines for long-distance; paper is entirely based on Austrian conditions. Bibliography.

Combustion. Combustion-Chamber Progress Correlated, A. Taub. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 413–443, 42 figs. Analysis of combustion-chamber design based on research of Ricardo, Janeway and Whatmough; common principles are cooling last gas to burn by means of shallow clearance space; locating spark plug near exhaust valve; non-compact combustion chambers; volume control for smoothness; controlling acceleration of rise in pressure, to prevent roughness.

Indicators. Alterations and Tests of the "Farnboro" Engine Indicator, J. H. Collins, Jr. Nat. Advisory Committee for Aeronautics—Tech. Note No. 348, Sept. 1930, 14 pp., 5 figs. "Farnboro" electro-pneumatic indicator was tested as received from manufacturers and modifications made to improve its operation; modified indicator gives complete record of average cyclic variation in pressure per crank degree for any set of engine operating conditions which can be held constant for period of time required to build up composite card.

Stresses. Stresses in Internal-Combustion Engines (Beanspruchungen an Verbrennungskraftmaschinen). Automobiltechnische Zeit. (Berlin), vol. 33, no. 25, Sept. 10, 1930, pp. 604–606, 6 figs. Discussion and compilation of formulas for computing stresses in principal parts of various types of internal-combustion engines; data on customary gas velocities.

Valve-Clearance Measurement. A Valve-Clearance Indicator, F. Jehle. Soc. Automotive Engrs.—Jl., vol. 27, no. 4, Oct. 1930, pp. 473–474, 4 figs. Optical arrangement for measuring valve clearance during operation of engine is illustrated by sketch; graphs show changes and clearances of inlet and exhaust valve at three engine speed.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; GASOLINE ENGINES; OIL ENGINES.]

IRON AND STEEL

Protective Coatings. Limitations of Cadmium and Zinc Coatings, K. A. Eckhardt. Am. Mach., vol. 73, no. 11, Sept. 11, 1930, pp. 429–432, 3 figs. Discussion of properties and tests of cadmium and zinc coatings under various conditions; graph shows results of exposure tests on cadmium and zinc electroplated samples under atmospheric and salt spray conditions.

L

LOCOMOTIVES

Design. Limits of Steam-Locomotive Design (Grenzen des Dampflokomotivbaues), E. E. Metzeltin. V.D.I. (Berlin), vol. 74, no. 34, Aug. 23, 1930, pp. 1179–1182, 4 figs. Limiting maximum output of locomotives under normal conditions; fuel supply; axle load; effect of limitations of profile on dimensions of cylinder and boiler diameter; sketch shows locomotive for 8000-hp., and 25-ton axle pressure with driving tenders on front and rear.

Fuel Economy. Consumption of Fuel in Locomotive Practice, H. Fowler. Engineer (Lond.), vol. 150, no. 3896, Sept. 12, 1930, p. 277. Consideration of method by which coal is consumed in locomotive firebox; it is fallacy to imagine that steaming capacity of locomotive boiler may always be increased by increasing number of tubes in barrel; firing methods. Paper read before Section G, Brit. Assn.

Oil-Electric. The Oil-Electric Locomotive, Its Limitations and Value, S. T. Dodd. Motive Power, vol. 1, no. 8, Sept. 1930, pp. 22–23 and 48, 4 figs. Consideration of design and operating characteristics; advantages of oil-electric type over steam locomotives; conclusion may be drawn that oil-electric locomotive presents advantage of highly efficient drive; disadvantage of power output strictly limited to capacity of its engine.

Performance. New Wabash Locomotives Make Good in Service Tests. Ry. Age, vol. 89, no. 13, Section 1, Sept. 27, 1930, pp. 616–618, 2 figs. Demonstrate about 22 per cent increase in capacity and fuel economy as compared with locomotives replaced; comparative dimensions of new mountain-type (M-1) and Mikado (K) locomotives on Wabash; ton-mile per train-hour performance; how dynamometer car tests were made; dynamometer-car test results; efficiency compared with that of other locomotives.

Valve Gear, Poppet. Holmes Poppet Valve Gear for Locomotives. Ry. Gaz. (Lond.), vol. 53, no. 12, Sept. 19, 1930, pp. 364–365, 3 figs. Perfect timing of valve events up to 84 per cent cut-off and interchangeability of left and right-hand cam boxes and cylinders are among advantages claimed for this gear; illustrated diagrams showing general arrangement of valve gear.

LUBRICANTS, CUTTING

Reclamation. Conveyor Washing Process Reclaims Oil From Turnings. Iron Age, vol. 126, no. 14, Oct. 2, 1930, pp. 922–924, 4 figs. Methods and equipment for recovering 6000 gal. of cutting oil daily from 120 tons of steel turnings at new Gambriuns plant of Timken Roller Bearing Co.; special pan conveyors with screen bottoms carry turnings through hot-water sprays; sketch shows "Rex" chip washing conveyor which extracts 96 to 98 per cent of cutting oil.

M

MACHINE PARTS

Strength Calculation. Machinery Parts and Properties of Materials (Maschinenteile und Werkstoffkunde), E. Heidebroek. V.D.I. Zeit. (Berlin), vol. 74, no. 37, Sept. 13, 1930, pp. 1259–1265, 22 figs. Effect of experiences and research in properties of material on design of machine parts; review of V.D.I. papers on endurance tests, strength calculation, design of large forgings, machine parts for high-pressure superheated steam, high-speed piston engines, belting, sliding clutches, low-speed friction coefficients.

MANAGEMENT

Cost Accounting. Modern Cost Work Shows Its Profit Possibilities, J. H. Van Deventer. Iron Age, vol. 126, no. 13, Sept. 25, 1930, pp. 833–835 and 903. Outline of functioning and duties of cost department and cost engineer; analysis of cost into overhead, power transmission, repairs, idle machines, management, etc.

Machine Shop Accounting With the Aid of Mechanical Methods, T. B. Frank. Iron Age, vol. 126, no. 14, Oct. 2, 1930, pp. 925–927 and 975–976, 5 figs. Use of mechanical tabulating equipment for sorting and analyzing pertinent facts; great utility of equipment lies in its ability to aggregate, by groups, information in any desired order; typical records and cards are illustrated.

Distribution Problems. Investigating and Analyzing Distribution, L. G. Cattermole. Paper Trade Jl., vol. 91, nos. 12, 13, and 14, Sept. 18, 1930, pp. 69–72, Sept. 25, pp. 61–64 and Oct. 2, pp. 65–67. Sept. 18: New form of management in modern enterprises has changed selling methods; outline of varied subjects relating to sales which should generally be studied and correlated into complete program; other factors in conduct of business. Sept. 25: Analysis of market; channels of distribution; exclusive representation; cost of distribution. Oct. 2: Office and field organization; directing and supervising salesmen; methods of compensation; advertising.

Motion Study. Micromotion Study Applied to Manufacture of Small Parts, R. M. Blakelock. Factory and Indus. Mgmt., vol. 80, no. 4, Oct. 1930, pp. 730–732, 6 figs. Fundamentals of applied micromotion study, illustrated with several cases selected from practice.

Production Control. For Production Control of Our 350-Item Line Figures Beat Guesses, R. L. Flett. Factory and Indus. Mgmt., vol. 80, no. 4, Oct. 1930, pp. 719–721 and 757, 1 fig. Method of control of 350-item line of house hold and toilet articles used by American Products Co., Cincinnati, by which forecast of production is made ten weeks ahead, number of workers required is determined four weeks ahead, employment of persons with no special training is made possible.

MANGANESE STEEL

Heat Treatment. Heat Treatment Determines Manganese Steel Properties, H. P. Evans. Steel, vol. 87, no. 11, Sept. 11, 1930, pp. 66–68. Brief outline of heat-treating method for manganese steel and discussion of reasons for structural changes; data on composition and hardness.

METALS

Cold Working. Variations in Hardness of Metals, and Alloys Resulting From Cold Working (Sur les variations de dureté de certains métaux et alliages en fonction de l'écrouissage), Guichard, Clausmann, and Billon. Académie des Sciences—Comptes Rendus (Paris), vol. 190, no. 2, Jan. 13, 1930, pp. 112–114, 1 fig. Increase in hardness caused by cold working of 10 metals and alloys used for coinage was investigated by cold rolling sheets of completely annealed metals and determining relation between deformation and Brinell hardness; results expressed by curves.

Elastic Hysteresis. Elastic Hysteresis of Materials Under Alternating Normal and Shearing Stresses (Die Daempfung der Werkstoffe bei wechselnden Normalspannungen und bei wechselnden Schubspannungen), O. Foeppl. V.D.I. Zeit. (Berlin), vol. 74, no. 40, Oct. 4, 1930, pp. 1391–1394, 8 figs. Classification of elastic hysteresis phenomena; practical value of elastic hysteresis; comparative study of hysteresis curves for normal and shearing stresses.

MOLDING MACHINES

Foundry. Mechanical Handling Methods in Stove Manufacture, H. Magdelenat. Mech. Handling (Lond.), vol. 18, no. 9, Sept. 1930, pp. 297–298, 1 fig. Continuous handling operations embodied in Rosieres-Bachon molding machine for repetitive production of castings in stove manufacture; a plan and elevation views of continuous molding machine layout are illustrated. Paper read before Inst. Brit. Foundrymen, previously indexed from Foundry Trade Jl., July 10, 1930.

MOTOR TRUCKS

Design. Weight and Size Trends in Motor-Truck Development, P. Schon. Soc. Automotive Engrs.—Jl., vol. 27, no. 2, Aug. 1930, pp. 187–193 and (discussion) 193–196, 1 fig. General discussion of progress in motor-truck design particularly with regard to chassis and load capacity; notes on straight-rating formula; practical scale of eight load-space dimensions ranging from 39 in. from cab to center line of rear axle for small 6-ft. delivery body to 135 in. for 21 ft. moving van is recommended.

N

NITRIDATION

Continuous. Continuous Nitriding a New Development, R. J. Cowan. Metal Progress, vol. 18, no. 4, Oct. 1930, pp. 93–98, 5 figs. Nitridation process for high and low-temperature treatment and furnace equipment developed by Surface Combustion Co., Toledo, O.; sketch shows gas-fired muffle furnace with airlocks and seals at entrance and exit; graph illustrates relations between depth of nitrided case hardness and degree of dissociation and time.

Methods. Nitriding or Casehardening With Ammonia, V. O. Homerberg and J. P. Walsted. Machy. (N. Y.), vol. 37, no. 2, Oct. 1930, pp. 106–108. Discussion of nitriding methods to produce parts that have tough inner core and surfaces with outstanding wear-resisting qualities; kinds of steel that can be nitrided; temperature required and time of exposure; experiments at temperatures ranging from 900 to 1300 deg. fahr., inclusive, show that depth of case increases, but hardness decreases with increase in temperature. Abstract of paper read before A.S.M.E., Sept. 22–24, 1930.

Recent Developments in. Recent Developments in Nitriding, R. Sergeson. Iron Age, vol. 126, no. 11, Sept. 11, 1930, pp. 680–682, 6 figs. Outline of types of nitriding analysis now found on commercial market as to many applications in industry; new free machining high-sulphur nitriding steel is reviewed as to its machinability and nitriding qualities; method of protection against nitriding with sodium silicate, chrome ore mixture.

NOISE

Measurement of. Practical Methods of Noise Measurement, E. E. Free. Acoustical Soc. of America—Jl., vol. 2, no. 1, July 1930, pp. 18–29, 4 figs. Noisiness of noise; noise units; historical developments in methods and measuring equipment; audiometer methods; number 3-A audiometer described; acoustimeter methods; modern acoustimeter recently developed by C. F. Burgess Laboratories, Inc., characteristics of acoustimeter; noise measurement with tuning forks; comparison of methods.

Physical Effects. The Effect of Noise Intensity and Pattern on Locating Sounds, W. G. King and D. A. Laird. Actual Soc. of America—Jl., vol. 2, no. 1, July 1930, pp. 99–102, 1 fig. Experiments concerned with more practical question of how one's accuracy in detecting direction from which sound comes to his ears is affected by noise present at that time in hearer's surroundings.

O

OIL ENGINES

Combustion. Antechambers and the High-Speed Oil Engine Combustion Problem, R. Matthews. Motive Power, vol. 1, no. 8, Sept. 1930, pp. 19–21 and 46, 5 figs. Questions pertaining to relative merits of ante-chambers and single combustion chamber design; specific reference to above factors are considered.

Starting. Rapid Starter for Internal-Combustion Engines (Schnellanlasser fuer Verbrennungsmotoren), H. Lang. V.D.I. Zeit. (Berlin), vol. 74, no. 38, Sept. 20, 1930, pp. 1325–1328, 12 figs. Starting methods for low-compression oil engines are illustrated by sketches; rapid burners, electrical, pyrochemical, and glow-tube designs.

OPEN-HEARTH FURNACE

Practice. Open-Hearth Furnace Steelworks, H. C. Wood. Iron and Steel of Canada (Gardenvale, Que.), vol. 13, no. 9, Sept. 1930, pp. 194–197, 213 and 215, 4 figs. Comparison of practice followed and results obtained in Great Britain and Germany and other leading Continental steel-producing countries; tables and graphs illustrate production of open-hearth steel according to process and country; typical operation data.

P

PHOTOELASTICITY

Stress Analysis. Stress Analysis by Means of Polarized Light (Ueber die Untersuchung ebener Spannungszustaende mit Hilfe von polarisiertem Licht), M. Waechtler. V.D.I. Zeit. (Berlin), vol. 74, no. 17, Apr. 26, 1930, pp. 545–546, 13 figs. partly on p. 547. Review of recent progress in theory and practice of photoelastic methods of stress analysis and of early German work on optical properties of materials used for construction of models.

PIPE

Heat Transmission. Relation of Mean Heat Transfer Coefficient of Length of Pipe (Die Abhaengigkeit der Mittleren Waermeuebergangszahl von der Rohrlaenge), W. Stender. Wissen-

schaftluchungen aus dem Siemens-Konzern (Berlin), vol. 9, no. 2, June 12, 1930, pp. 88–98, 5 figs. New equation is developed for temperature relations and heat transfer in heated pipes; new equation is applied to experiments by Nusselt, Rietschel, Stanton, and Stander for verification of their constants derived for gases and water.

PIPE LINES

Design. Calculation of Pipe Lines for Viscous Fluids (Berechnung von Rohrleitungen fuer Zaehe Fluessigkeiten), W. Guntermann and H. Kroessin. Waerme (Berlin), vol. 53, no. 38, Sept. 20, 1930, pp. 704–706, 6 figs. Simple values are given for relation between friction coefficient and Reynolds coefficient in dependence upon nature of flow; influence of temperature on viscosity and therefore, on Reynolds coefficient and flow conditions; by applying this calculation to flow of tar, limit values are obtained for temperature, diameter and speed as basis for economic design of pipe lines.

POWER PLANTS

Tidal. The Shishkoff Hydro-Thermal Tidal Power System. Engineer (Lond.), vol. 150, no. 3898, Sept. 26, 1930, pp. 330–333, 10 figs. Experimental plant erected at Old Lock, Avonmouth Docks; Shishkoff system makes use of thermal storage; vertical shaft of water turbine is coupled directly to Heenan and Froude brake and to vertical alternator; energy delivered by water turbine is in part directly converted into electricity for immediate consumption and in part converted into heat; water which receives heat generated inside brake is circulated by pump in closed circuit between brake and Ruths steam accumulator.

PRESSURE GAGES

Mercury. The Measurement of Pressures in Mercury, P. A. Redford. Mech. World (Lond.), vol. 88, no. 2279, Sept. 5, 1930, pp. 266–227, 3 figs. In contrast to column of water, level of which rises in consequence of capillary attraction in narrow pipes, column of mercury is reduced in height due to surface tension of mercury; depressions, which depends on pipe diameter and height of mercury column, must be taken into consideration in determining pressure to be measured; table giving depression in millimeters of mercury, and water column, for different internal diameters of glass tubes.

PRESSURE VESSELS

Design. Correlating Theory and Practice in Pressure-Vessel Design, N. W. Krase. Chem. and Met. Eng., vol. 37, no. 9, Sept. 1930, pp. 540–543, 11 figs. Review of fundamentals of design of pressure vessels; difficulties encountered when very high pressures and temperatures are involved.

Welding. The Strength and Design of Fusion Welds for Unfired Pressure Vessels, L. W. Schuster. Instn. Mech. Engrs.—Proc. (Lond.), no. 2, Mar. 1930, pp. 319–377 and (discussion) 378–422, 26 figs. Object, scope and need of investigation; conclusions reached on mechanical construction of welded vessels; various tables and figures are given illustrating extent of investigation; appendix of provisional rules for fusion-welded non-fired pressure vessels. Paper previously indexed from various sources.

PULVERIZED COAL

Russia. Pulverized Fuel Practice in the U.S.S.R., L. K. Ramzin. World Power (Lond., vol. 14, no. 81, Sept. 1930, pp. 247–254. Account of pulverized-fuel practice in Russia; author states that belief commonly held concerning expensiveness of pulverized-fuel plant as compared with mechanical stoker is entirely erroneous, though only so far as unit system is concerned; unlike other countries whose practice it is to use coals with high content of volatile for pulverized fuel combustion, Russia is burning powdered fuel with low volatile content, is using such varieties as anthracite culm and lean coal. Abstract of paper presented before World Power Conference, Berlin, June 1930.

PUMPS, CENTRIFUGAL

Self-Priming. Self-Priming Centrifugal Pump of Unusual Pumping Lift (Ungewoehnliche Foerderhoehe einer selbstansaugenden Kreiselpumpe), C. Ritter. V.D.I. Zeit. (Berlin), vol. 74, no. 37, Sept. 13, 1930, pp. 1257–1258, 5 figs. Abstract of report on construction and tests of so-called Sihi pump manufactured by Siemen & Hinch m.b.H.; by means of special channels, nearly concentric with casing, pump is enabled to acquire multi-stage effect equivalent to 5 times lift expected of ordinary pump rotor of equal speed.

Turbine. Experimental Researches on Turbine Pumps, M. Yendo. Yokohama Technological College—Reports (Yokohama), no. 1, June 1930, 96 pp., 293 figs. partly on plates. Experiments to determine mainly pressure, velocity, and direction of flow of water just after leaving impeller and entering diffusor ring; also diffusor efficiency and entrance conditions by aid of subsidiary measurements. (In English.)

R

RAIL MOTOR CARS

Gasoline-Electric. Gas-Electric Motor Rail Cars, Canadian Pacific Railway. Can. Ry. and Mar. World (Toronto), no. 390, Aug. 1930, p. 495, 1 fig. Design and constructional features of two gas-electric rail motor cars recently received for passenger service on branch line; list of principal dimensions is given; power plant consists of 400-hp. engine, 8-cylinder, 8-in. bore, 10-in. stroke, model 148, Winton Engine Co.

Steam. Sentinel Rigid Eight-Wheeled Wagon. Engineering (Lond.), vol. 130, no. 3374, Sept. 12, 1930, pp. 326–327, 6 figs.; see also Engineering (Lond.), vol. 150, no. 3896, Sept. 12, 1930, pp. 290–291, 6 figs. Particulars of steam car, carried on two 4-wheeled trucks one fore and one aft; forward truck is of entirely new design; all four front wheels are steered on Ackermann principle.

Testing. Comparative Tests of Rail Motor Cars Using Gasoline, Distillate and Fuel Oil, Can. Ry. and Mar. World (Toronto), no. 390, Aug. 1930, pp. 487–490, 6 figs. Part of report by committee on automotive rolling stock presented before American Railway Association, Mechanical Division, covering test data in tabular form, and accompanying illustration showing correction curves for main generator and exciter watt-hour meters, profiles of lines over which Canadian National Railways test cars were run, and typical sections of graphs showing power output; in most cases trailers were hauled by cars under test.

REFRIGERATION

Multi-Temperature Systems. Multiple-Temperature Refrigerating Systems, H. Mawson. Liverpool Eng. Soc.—Trans. (Liverpool), vol. 51, 56 session, 1930, pp. 101–120 and (discussion) 121–134, 5 figs. Consideration of several systems in which two or more refrigerators may be kept at different temperatures by same machine; examination of theoretical performances and practical requirements.

ROLLING MILLS

Design. Energy Required and Forces Developed in Rolling Mills, A. W. Knight. Mech. World (Lond.), vol. 88, nos. 2280, 2281, Sept. 12, 1930, pp. 248–251, Sept. 19, pp. 263–265, 10 figs., Sept. 26, pp. 290–294, 2 figs. Phenomena in rolling of hot and plastic steel; formulas for forces exerted on housings or rolls, torque on rolls, energy required for pass, horsepower necessary, and total amount of deforming energy required to roll from ingot or billet to finished section; frictional losses in roll journals; differences in efficiency of these journals explain why mills having small-diameter rolls absorb less energy to produce certain deformations than mills having large rolls. Values of plastic stress "f" and experimental verification of formulas on six different rolling-mills, all electrically driven; effect of rate of deformation on value of "f;" total amount of energy required to roll from ingot or billet to finished section.

Roller-Bearing. Power Consumption Tests on the Timken Steel and Tube Company Blooming and Bar Mills, F. Waldorf. Iron and Steel Engr., vol. 7, no. 9, Sept. 1930, pp. 442–460 and 466–468, 23 figs. Discussion of test results with particular regard to effects of roller bearings; graphs illustrate data on rolling pressures, temperatures, reductions and elongations.

Results Obtained With Roller Bearings in Rolling Mills, G. E. Palmgren. Iron Age, vol. 126, no. 12, and 13, Sept. 18, 1930, pp. 778–781 and Sept. 25, pp. 855–859, 18 figs. Sept. 18: Discussion of design and application of roller bearings particularly to rolling mills, based on experience of SKF industries; two-bearing design for ordinary hot rolling mills; sketches show distribution of pressure and methods of absorbing actual trust. Sept. 25: Tables give data on power economy measurements in wire rolling mill and rolling of steel strips in medium mill.

ROLLS

Failures. Sheet and Tinplate Rolls, J. S. Caswell, Iron and Coal Trades Rev. (Lond.), vol. 121, no. 3259, Aug. 15, 1930, pp. 217–218. Roll-breakage records; loads set up by deformation of iron; roll temperature; thermal variations with falling face temperature; discussion. Extracts from paper read before South Wales Inst. of Engrs.

S

SAWS, WOODWORKING

Filing Machines. Automatic Band-Saw Filing and Setting Machine. Engineering (Lond.), vol. 130, no. 3372, Aug. 29, 1930, pp. 265–266, 3 figs. Machine made by Wadkin and Co. can be used exclusively for sharpening or setting, or for both; first of these operations is effected by means of standard three-cornered file; for second special device is provided which is readily attached after removal of file.

SCREW THREADS

Dardelet Self-Locking. The Dardelet Self-Locking Screw Thread. Engineering (Lond.), vol. 130, no. 3372, Aug. 29, 1930, p. 282, 3 figs. In this device forms of threads for nut and bolt are somewhat different; portion of bolt between threads is made slightly tapered, with parts of smaller diameter nearer head, i.e., toward left in figures, while crests of threads in nut are tapered to same angle in both directions.

SHEET-METAL TESTING

Methods and Apparatus. Method and Apparatus Giving Extension Coefficient and Breaking Load of Metallurgical Products in Thin Sheets (Methode et appareil d'essai donnant le coefficient d'extension et la charge de rupture des produits métallurgiques en feuilles), C. Jovignot. Académie des Sciences—Comptes Rendus (Paris), vol. 190, no. 22, June 2, 1930, pp. 1299–1302, 2 figs.; see also brief translated abstract in Chem. and Industry (Lond.), vol. 49, no. 34, Aug. 22, 1930, p. 772. Test piece is pressed tightly between two circular jaws, and measured hydraulic pressure is applied through reservoir below it till rupture of leather sphere occurs; nature of break furnishes indication of homogeneity of test piece.

Testing Method and Apparatus Giving Coefficient of Expansion and Breaking Load of Metallurgical Sheet Products (Méthode et appareil d'essai donnant le coefficient d'extension et la charge de rupture des produits métallurgiques en feuilles), C. Jovignot. Revue de Métallurgie (Paris), vol. 27, no. 8, Aug. 1930, pp. 443–448, 10 figs. Method described consists of submitting specimen sheet clamped between circular jaws to direct action of liquid; advantages of method are set forth.

Testing of Thin Sheets With Deep Drawing Hole-Widening Test (Die Pruefung von Feinblechen durch den Tiefzieh-Weitungsversuch), E. Siebel and A. Pomp. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf (Duesseldorf), vol. 12, no. 9, 1930, pp. 115–125, 15 figs. partly on supp. plate. Authors' previously indexed paper in vol. 11, no. 8, 1929 issue, described cupping test using disk test piece in which central hole was cut; stretch of material during cupping occurs by radial flow outward from central circular hole, which gradually widens; tests on sheet and strip steel and non-ferrous metals, and on coarse-grained recrystallized metal.

SMOKE ABATEMENT

Progress in. Smoke Abatement Progress, V. J. Azbe. Power Plant Eng., vol. 34, no. 19, Oct. 1, 1930, pp. 1102–1104, 5 figs. Improved methods for domestic and industrial firing; fundamentals for smoke elimination; performance curves for steam heating boiler with and without down-draft baffle; arrangement of down-draft baffle in firebox of heating boiler. Paper presented before World Power Conference, Berlin, June 1930.

SOUND INSULATION

Measurement of. Measurement and Calculation of Sound-Insulation, V. O. Kundsen. Acoustical Soc. of America—Jl., vol. 2, no. 1, July 1930, pp. 129–140, 3 figs. Author has made some insulation measurements by three different typical methods now in use at different laboratories, and obtains good agreement for coefficients of transmission by all three methods; by assigning reasonable properties to test rooms at Riverbank Laboratories it is shown that Sabine's results on insulation of rigid partitions are in essential agreement with Chrisler's results; simple formula is suggested for calculating insulation properties of rooms.

SPEED REDUCERS

Stepless. A New Stepless Speed Reducer, G. Erényi. Eng. Progress (Berlin), vol. 11, no. 10, Oct. 1930, pp. 270–271, 4 figs. A.E.G. variable-speed reducer is friction gear in which torque of driving shaft is transmitted to driven shaft through stationary set of inclinable rollers kept in contact with their track surfaces with pressure sufficient to ensure effective power transmission.

SPRINGS

Testing. Determination of Elastic Limit and Creep Limit of Spring-Steel Wire by Means of Torsional Test (Die Bestimmung der Elastizitaetsgrenze und der Fliessgrenze von Federstahldraht durch den Verwindungsversuch), E. Siebel and A. Pomp. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf (Dusseldorf), vol. 12, no. 7, 1930, pp. 85–91, 10 figs. Principles underlying comparison of tensile, compression, and torsional tests; displacements as measure of deformation; comparison of flow curves for tension, compression and torsion; development of simplified testing method for spring-steel wire.

STEAM

Distribution in Industrial Plants. Economical Production and Distribution of Steam in Large Factories, F. Carnegie. Instn. Mech. Engrs.—Proc. (Lond.), no. 2, Mar. 1930, pp. 473–526 and (discussion), 527–552, 22 figs. Factors involved in steam generation in English industrial power plants; survey of existing conditions; economical distribution or conveyance of steam from generating center to user center; system of accounting which would accurately reflect unit cost of steam at each generating and user center; checking consumption and accounting for steam used; results of steam investigation at Woolwich Arsenal. Paper previously indexed from various sources.

High-Pressure. High-Pressure Steam—A Money Saver in Process Plants, P. W. Swain. Chem. and Met. Eng., vol. 37, no. 9, Sept. 1930, pp. 568–569, 1 fig. Examples of wide application of high-pressure steam both in United States and abroad.

Properties of. A Review of Calorimetric Measurements on Thermal Properties of Saturated Water and Steam, E. F. Fiock. U. S. Bur. of Standards—Jl. of Research, vol. 5, no. 2, Aug. 1930, pp. 481–505, 6 figs. Review prepared to assemble data available on calorimetric determinations of thermal properties of saturated water and steam and to reduce them to uniform basis for comparison; possible causes for variation among recorded results; several modern steam tables are compared graphically with one another and with National Bureau of Standards experimental results on thermal properties of saturated liquid and vapor; marked improvement in tables is evident with increase in scope and reliability of basic experimental data.

A Calorimetric Determination of Thermal Properties of Saturated Water and Steam From 0 to 270 Deg. C., N. S. Osborne, H. F. Stimson, and E. F. Fiock. U. S. Bur. of Standards—Jl. of Research, vol. 5, no. 2, Aug. 1930, pp. 411–480, 13 figs. partly on supp. plate. Method, apparatus, measurements, results, and formulations involved in work on steam which has been completed to date at National Bureau of Standards.

Heat of Vaporization of Water and Specific Volume of Saturated Steam up to 310 Deg. Cent. (100.7 Atmos) [Die Verdampfungswaerme des Wassers und das spezifische Volumen von attdampf im Bereich bis deg. (100.7 at.)], M. Jakob and W. Fritz. V.D.I. Zeit. (Berlin), vol. 74, no. 37, Sept. 13, 1930, pp. 1266. Abstract of report from German Government Institute of Engineering Physics on methods and results; results are compared with those of Osborne, Stimson, and Fiock of U. S. Bureau of Standards, also with those of Keenan and Callendar.

STEAM CONDENSERS

Maintenance and Repair. Improving Plant Operation by Condenser Maintenance. Power Plant Eng., vol. 36, no. 18, Sept. 15, 1930, pp. 1035–1038, 11 figs. Clean tubes, air and water leakage form important factors in successful condenser performance; typical condenser layout of modern power plant is illustrated.

Surface. Principles of Surface Condenser Design. Mech. World (Lond.), vol. 88, no. 2281, Sept. 19, 1930, pp. 274–278, 7 figs. Outline of fundamental thermodynamic relations and formulas; critical investigation of influence of various factors upon which performance of condenser depends; effect of limited conductivity; influence of pressure drop over tube nest.

STEAM-ELECTRIC POWER PLANTS

Design and Operation. Design and Operation of Super Power Plants (Bau und Betrieb von Energie-Grossanlagen), H. Gleichmann. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 9, Sept. 1930, pp. 299–300. Interchange of energy between states; planning of large electric works; most economic steam pressure; intermediate superheating; peak-load power plants; momentary reserve. Paper read before World Power Conference, Berlin.

Testing. Power-Plant Testing, P. H. Hardie. Engineering (Lond.), vol. 130, no. 3374, Sept. 12, 1930, p. 324. Letter to editor referring to article by Guy and Lamb, on Operating Results With Recent Extensions of Barton Power Station, previously indexed from May 9 and 16 issues of this journal; under classification Steam-Electric Power Plants—Great Britain, present writer, who is test engineer of Brooklyn Edison Co., criticizes fact that test heat consumption was reported only to number of significant figures; he believes that accuracy of plus or minus 0.5 per cent is best than can be obtained consistently on turbo-generator units tested in operation in power station.

STEAM POWER PLANTS

Equipment. Boilers, Superheaters, and Economizers. Nat. Elec. Light Assn.—Pub., no. 0-1, Aug. 1930, 34 pp., 61 figs. In 1929 boiler which produced 1,250,000 lb. of steam per hr. was used; steam pressure and temperature have increased; there are more than 15 boilers operating at 1400 lb. or more and steam temperature in large number of stations is 750 deg. fahr. knowledge of control of caustic embrittlement has been greatly extended; use of water-cooled furnace walls, particularly on large units, is almost standard practice; methods of welding have progressed.

Steam and Gas Turbines and Reciprocating Engines (Dampf und Gasturbinen und Kolbenmaschinen), E. A. Kraft. Archiv. fuer Waermewirtschaft (Berlin), vol. 11, no. 10, Oct. 1930, pp. 325–328. Generation of power steam; intermediate superheating; back-pressure and bleeder turbines; operating costs and statistics; high-pressure reciprocating engines; economic limits between reciprocating steam engines and turbines; gas engines and gas turbines; binary-vapor processes; it is believed that no other prime mover will replace steam turbine in some time to come, and that steam power plants will remain in ascendency. Paper read before World Power Conference, Berlin.

Reconstruction Reorganising an Industrial Boiler Plant. Eng. and Boiler House Rev. (Lond.), vol. 44, no. 3, Sept. 1930, pp. 162, 164, and 166, 3 figs. Description of new plant and equipment of York Street Flax Spinning Co., Ltd., Belfast; efficiency as high as 88 per cent is reported with evaporation of 36,000 to 41,000 lb. of steam per hr., using coal with gross calorific value of 12,014 B.t.u. per lb.

STEAM TURBINES

Efficiency Charts. A Steam Turbine Efficiency Chart, F. C. Martin. Australasian Elec. Times (Melbourne), vol. 9, no. 8, Aug. 27, 1930, pp. 499–500, 1 fig. Chart incorporates all steam properties and data required by turbo-electric plant engineer to check up on efficiency of his plant, and thus detect deterioration therein, mismanagement, mud in condenser tubes, air leakage to condenser, etc. Presented at World Power Conference, Tokyo, 1929.

Overloading. Steam Turbine Overloads, C. A. Parsons and R. Dowson. Elec. Rev. (Lond.), vol. 107, no. 2755, pp. 435–437, 3 figs. Case for use in power stations of steam turbines having larger emergency ratings than are at present usually specified; steam-turbine design for wide ranges of load; alternators with artificially increased ratings; comparative costs. Abstract of paper presented before World Power Conference.

STEEL

Alloy. See ALLOY STEEL.

Cold Working. Cold Rolling Raises Fatigue or Endurance Limit, G. S. von Heydekampf. Iron Age, vol. 126, no. 12, Sept. 18, 1930, pp. 775–777 and 829, 4 figs. Investigation of endurance limits and elastic behavior with special attention to mechanical hysteresis effect for ranges of stress within elastic and fatigue limits; influence of surface and surface damage on fatigue strength; by cold rolling surface of machine parts fatigue or endurance limit can be raised about 15 per cent.

Hardness Testing. Hardness Tests of Steel Strip, G. A. Hankins. Engineering (Lond.), vol. 130, no. 3374, Sept. 12, 1930, p. 324. Letter to editor containing remarks and results of tests carried out at National Physical Laboratory; typical series of tests in Vickers machine are given in table, material being steel strip 0.0152 in. in thickness.

Heat Treatment. Steel and Its Heat Treatment for Parts That Must Resist Wear, H. W. McQuaid. Heat Treating and Forging, vol. 16, no. 9, Sept. 1930, pp. 1159–1162 and 1164, 5 figs. Relative status and economy of different steels and treatments which can be used where hard surface is required; curves showing depth hardness relation of various steels and treatments; notes on nitriding; use of low-carbon steel and low-carbon alloy steel.

Manganese. See MANGANESE STEEL.

T

TEMPERATURE SCALE

International. Experimental Bases of International Temperature Scale in Low-Temperature Range (Die experimentellen Grundlagen der internationalen Temperaturskala, etc.), F. Henning. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 37, no. 9, Sept. 1930, pp. 169–174. Following points have been established: within measuring accuracy of plus or minus 0.03 deg., internationally accepted relation between resistance of platinum wire and gas-thermometrically determined temperature holds true within range of minus 190 to 0 deg.; platinum resistance thermometers of varying platinum purity calibrated according to international regulations give temperature values agreeing within plus or minus 0.01 deg.

TURBINES

Spiral Casings. Theory and Design of Spiral Casings (Theorie und Konstruktion von Spiralgehaeusen), B. Eck. Werft-Reederei-Hafen (Berlin), vol. 11, no. 14, July 22, 1930, pp. 309–318, 17 figs. Hydrodynamic principles of design of spirals for turbo-machinery are developed; for spirals with parallel and conical lateral walls with circular and rectangular cross-sections, exact formulas are derived, which permit recording of spirals; influence of wall friction on spiral itself and on rotor; theoretical treatment and practical experiments show that practice of disregarding friction in spiral, in case of single-stage turbo-machinery, often leads to faulty design.

W

WELDING

Electric. See ELECTRIC ARC WELDING.

Iron and Steel Plants. Welding in Steel Plants (Schweissen in Huettenwerken), Adran. V.D.I. Zeit. (Berlin), vol. 74, no. 19, May 10, 1930, pp. 610–611. Abstract of following papers, presented at meeting of Welding Committee of Society of German Engineers: Acetylene or Arc Welding in Steel Works, Drescher; Water-gas Welding for Manufacture of Containers, Boilers and Pipes, Pohl; Progress in Development of Weld Metals, Hoffmann; Transfer of Metal in Arc Weldings, Hilpert.

WELDS

Stresses in. Distribution of Stress in Parallel Welding Fillets, H. M. MacKay and A. M. Bain. Can. Jl. Research (Ottawa), vol. 3, no. 3, Sept. 1930, pp. 260–271, 11 figs. Mathematical theory is developed for distribution of stress in welded joints with parallel fillets, in case where each of members connected by weld is of uniform cross-section; theory is verified by strain measurements on two specimens of type of joint considered.

Stress Distribution in Side-Welded Joints, W. H. Weiskopf and M. Male. Am. Welding Soc.—Jl., vol. 9, no. 9, Sept. 1930, pp. 23–48, 17 figs. Three new features in connection with side-welded joints, that is, joints in which welds are disposed parallel to direction of stress—they are theory as to manner in which welds deform under shearing loads; means of determining effective areas of bars composing such joint; method of determining length of welds, such that maximum shear stress will not exceed average design stress by more than any desired ratio.

Testing. Classification and Physical Tests for Various Types of Welded Plate Joints, G. R. Exley. Gen. Elec. Rev., vol. 33, no. 10, Oct. 1930, pp. 581–591, 8 figs. Variables affecting classification; comparison of rolled steel and deposited steel; effects of ductile extensibility; test specimens; test results; comparison of characteristics.

Fatigue and Impact Tests for Welds, C. H. Jennings. Am. Welding Soc.—Jl., vol. 9, no. 9, Sept. 1930, pp. 90–104, 13 figs. Need of fatigue tests and problems encountered in making them; information obtained by author on impact strength of arc welds.

Magnetic Testing of Butt Welds, T. R. Watts. Am. Welding Soc.—Jl., vol. 9, no. 9, Sept. 1930, pp. 49–68, 17 figs. Magnetographic method has been employed experimentally by Research Laboratories, Westinghouse Electric and Manufacturing Co., for nearly two years; several minor variations and improvements developed during this time are described.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 52 December, 1930, Section Two Number 12

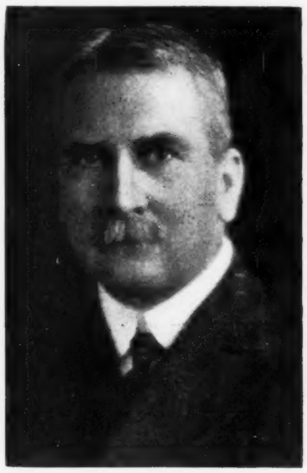
What It's All About

FOR two years this brief supplement to MECHANICAL ENGINEERING has summarized the contents of each month's issue. After a group of articles has been assembled, edited, and put into type it assumes an individuality and significance that justify some words of comment to give the busy or non-technically-minded reader a rapid survey of what is offered in the papers themselves. A "balanced ration" of reading in fields of interest to mechanical engineers is aimed at in making up the contents of every issue. The list for December has plenty of variety. This supplement tells "what it's all about."

Two Engineers Honored

TWO engineers have recently been greatly honored by their fellows. They are Dr. Elihu Thomson, of the General Electric Company, and Admiral David Watson Taylor, of the United States Navy.

DR. ELIHU THOMSON



ADM. DAVID WATSON TAYLOR

Dr. Elihu Thomson has been elected to Honorary Membership in The American Society of Mechanical Engineers. His crowning achievement which prompted his election has been the development of the technique of making quartz lenses for use in telescopes. Dr. Thomson has many honors and a long list of achievements in engineering and science to his credit. Aside from his work on quartz lenses, some of his important contributions to the world's welfare and knowledge are: discovery of the laws governing the electric arc; invention of an arc-light dynamo and regulator; first utilization of a magnetic field to move an electric arc; discovery of alternating-current repulsion phenomena, the basis of the alternating-current motor; building of high-frequency dynamos and transformers; invention of electric welding by the incandescent method; invention of electric watthour meter; first to make stereoscopic X-ray pictures.

Admiral Taylor has been awarded the John Fritz Medal by a board consisting of representatives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. These societies have a total membership of 65,000.

The citation accompanying Admiral Taylor's award reads: "For outstanding achievement in marine architecture, for revolutionary results of persistent research in hull design, for improvement in many types of warships, and for distinguished services as Chief Constructor in the United States Navy during the World War." Some recent recipients of the John Fritz Medal are Herbert Hoover, Ralph Modjeski, Edward Dean Adams, John F. Stevens, Ambrose Swasey, and Senatore Guglielo Marconi.

Power From Tropical Seas

ON OCTOBER 22, Georges Claude, fresh from triumphs over natural hazards and eager to confound his critics, delivered a lecture before the Metropolitan Section of the A.S.M.E. in New York on the success he had attained with his power plant at Matanzas Bay, Cuba, where, by utilizing the surface water as a source of steam and deep-sea water for condensing purposes, he had generated electrical energy in a fuelless steam-power plant. The lecture is published as the leading article in the December issue of MECHANICAL ENGINEERING.

Dr. Claude's lecture is significant from three points of view. First, it is a report of what was actually accomplished in Cuba. Second, it is of historical importance, regardless of what the future may prove as to the practicability of generating power from the tropical seas. Third, it is a human document of intense interest, revealing as it does the admirable qualities of character that have brought success to so many difficult ventures in science and engineering upon which Dr. Claude has embarked.

As to the accomplishments, they are briefly these; A plant was constructed at Matanzas Bay, Cuba, in which the warm water at the surface of the bay was transformed, under a partial vacuum, into vapor or low-pressure steam. This was led through a steam turbine to which an electric generator was coupled and was condensed by water drawn from the depths of the bay through a metal tube a little more than six feet in diameter and about a mile and a quarter long. The temperature of the surface water was about 27 deg. cent. (80.6 deg. fahr.) and the temperature of the water drawn from the depths of the sea about 13 deg. cent. (55.4 deg. fahr.). Dr. Claude was able to develop 22 kw. at the generator, using about 200 liters

(roughly 7 cubic feet) of warm water per second and the same amount of cold water.

From his tests Dr. Claude estimates that the energy available per cubic meter (slightly more than 35 cubic feet) of cold water per second in a large plant is more than 500 kw., assuming an equal consumption of warm water and a difference of temperature of 24 deg. cent. (43.2 deg. fahr.). Such a difference of temperature is available most of the year in the vicinity of Santiago de Cuba, where the next plant of 25,000 kw. capacity will probably be built. In much larger plants that will be demanded should the scheme prove practicable for commercial development, Dr. Claude estimates the construction cost at $60 per kilowatt, a cost that compares favorably with that of a modern fuel-burning steam-electric station.

The problem of fabricating and submerging the huge tube used by Dr. Claude for bringing the cold water up from the bottom of the ocean was solved after two disappointing and discouraging failures in a manner that is dramatically described in the lecture. Success in the operation of the plant came quickly after the installation of the tube, and tests upon which future designs are to be based were made. The commercial practicability of the system is yet to be demonstrated.

Of the historical importance of Dr. Claude's lecture there can be little room for argument. It reports an engineering experiment on a vast scale conducted to demonstrate the fact that a great source of natural energy may be found in tropical seas, and an actual experiment is much more convincing than theoretical speculation. Dr. Claude's critics may not be convinced, but at least they are respectful.

The human qualities of this remarkable document are apparent upon reading it. "Had I been less inured to the misfortunes of an inventor's life . . . .," writes Dr. Claude in describing the second failure to launch the big tube, and follows it up with, "It would have been denying all my past if, crushed by such a non-technical failure, I had then abandoned the job." Perseverance and obstinacy, he asserts, are the essential virtues in such work as his life has been devoted to, and these virtues have helped many other men.

ONE END OF DR. CLAUDE'S GREAT TUBE

This metal tube, slightly more than six feet in diameter and about a mile and a quarter long, was submerged in Matanzas Bay, Cuba, by Dr. Georges Claude, famous French inventor and scientist, in order to draw cold water from the bottom of the ocean to provide condensing water in his experimental steam power plant in which the warm surface water provides, without fuel, the steam to operate a turbine.

It is said of George Westinghouse that he contributed lavishly to scrap heaps. With perseverance and obstinacy, courage and self-assurance, he put his inventions into full-size and concrete form, sometimes to be justified by success, sometimes to meet total failure. He invested large sums of money and much time and engineering talent in schemes that others scoffed at, and frequently, as in the case of the air-brake trials in England, he was able to prove that he knew more than the experts. But he was never hampered by knowing too many things that could not be done. So it was with the Brothers Wright. So it has been with Dr. Claude.

Responsibility for Industrial Accidents

ACCORDING to the modern point of view, an industrial accident is evidence of some fault of control of operating conditions and forces. For this control the executives and members of the supervisory force are responsible. One study showed the supervisory force responsible for 88 per cent of all accidents. Thus does L. P. Alford, vice-president of the Ronald Press, New York, in a paper read at the A.S.M.E. Annual Meeting in New York, December 1 to 5, and printed in the December issue of MECHANICAL ENGINEERING assign the responsibility.

That engineering revision, that is, the application of engineering skill to the problems of safety in industry, has not heretofore been given all the credit deserved for its influence in the prevention of serious injury, is brought out by Dr. Lucian W. Chaney, expert in accident prevention, Bureau of Labor Statistics, U. S. Department of Labor, Washington, D. C., in the December issue of MECHANICAL ENGINEERING and presented at the same time as Mr. Alford's paper. Dr. Chaney's conclusions are drawn from a study of accident statistics. He shows that the careful appraisement by safety committees of some 1642 cases indicates that when adequate attention is given, engineering revision at once appears as of most importance in the control of serious injury. These two papers place a heavy responsibility on engineering management.

American Management in Europe

EVER since the days of Frederick W. Taylor, American engineers have been leaders in industrial management practices. As a result, their services are frequently sought by Europeans, and particularly since the war have some of the countries in Europe attempted to build up their industries by means of American management methods. Wallace Clark, consulting management engineer, is one of those who have had unusual opportunity through their services to clients in Europe to study conditions abroad. At the Annual Meeting, New York, December 1 to 5, 1930, of the A.S.M.E., Mr. Clark presents a paper on American Management in Europe. The paper will be found in the December issue of MECHANICAL ENGINEERING. Accompanying the paper, but not printed in MECHANICAL ENGINEERING, are numerous appendixes written by European engineers.

Mr. Clark has noted the following characteristics of European industry:

Less mass production than in America because of tariff walls, different habits of people, and lower purchasing power.

Turnover of investment is slower, due to less effective management.

Not enough practical men among the executives due to class distinctions.

Introduction of results of research into practice is slower.

More labor is wasted because wages are low.

There is more respect for knowledge and authority than in America.

Workmen have greater security.

These characteristics of industrial conditions in Europe apply only partly to Great Britain and not at all to Russia. In the latter the fundamental structure produces different shop conditions.

Installations of methods have been found to be most satisfactory when made by a combination of American and native engineers who train the clients' men, but do not undertake any executive work.

The following differences have been noted in the installation of the mechanisms of management:

In Europe more time is required to secure delivery of purchased materials.

The rearrangement of old buildings is more frequently necessary.

Reserved-time scheduling is more needed than chain production.

Market research and sales organization have not made much progress.

Budgeting is well understood.

Methods of executive direction are as much in demand as in America.

There is now in Europe a more general understanding of the fact that conditions are changing and that methods must be flexible.

The new management has brought to the worker better conditions, higher wages, and steadier employment.

The task of the management engineer, Mr. Clark states, is to place this science of management at the disposal of every part of industry in order to wipe out poverty and to give men more freedom to use their creative brains.

Markings on Bullets

IN THE February, 1930, issue of MECHANICAL ENGINEERING appeared the first of a series of articles dealing with markings on bullets and shells fired from small arms, by Prof. Charles O. Gunther, Stevens Institute of Technology, Hoboken, N. J. The second of the series will be found in the December issue.

When a bullet is fired through the barrel of a pistol or revolver, it is twisted in its travel by the rifling—spiral grooves made on the inside of the barrel. Scratches and grooves are made in the soft lead of the bullet or on its steel jacket during the passage through the barrel, and it seems possible that different markings are made by different weapons. It is argued by some persons that every weapon makes such strikingly individual marks that it is possible to identify the weapon from the scored bullet. Obviously, if this is true, a method is available by which persons accused of murder may be confronted with evidence difficult to controvert.

It must not be supposed that the identification of firearms from the bullets that have been shot from them is an exact science like fingerprinting. Those who make such claims are frequently required to prove the statement by the courts in which their testimony is offered, and their proofs are not always convincing. These persons, and those who write rashly on the subject in a pseudoscientific manner, bring discredit to what many recognize as a useful aid in the establishment of the guilt or innocence of those accused of murder.

By means of his studies, Professor Gunther is attempting to lay a rational basis for forming judgments in cases where the identification of firearms has been brought into legal proceedings. He is discussing with great care the innumerable factors which affect the problem from the point of view of an engineer who dispassionately examines the facts and the basis for them. He hopes that judges and juries will be able to find help through his studies in forming opinions as to what reliance can be placed in

methods of identification, and to show those who have the grave responsibility of establishing guilt or innocence how these marks are made and how they may be interpreted.

This is surely worth while. Professor Gunther's studies are not made under pressure of prosecution or defense attorneys to bring in evidence to convict or acquit, but are made in the spirit of science in his own laboratory. They should be gratefully received by all lovers of justice achieved through rational and intelligent means.

Motor-Car Engineering

AUTOMOBILE manufacturers have been able to maintain progress and meet the inevitable competition among themselves by means of research, development, and test organizations. Every year, and with some manufacturers more frequently, changes and improvements have made it possible for owners to turn in used cars for new ones reflecting the advances in motor-car design. Thus salesmen always have something new with which to tempt the buyer, and the motor-car owner is always dissatisfied with what he has because his car is out of date before the paint is dulled.

This rapid obsolescence is the result of constant engineering development, and is a factor characteristic of the automobile industry. In the December issue of MECHANICAL ENGINEERING, Col. Wm. G. Wall, consulting engineer, of Indianapolis, Ind., writes on engineering problems of modern motor cars and describes some of the modern tendencies in design. The features which Colonel Wall particularly emphasizes are number of cylinders, bore and stroke ratios, speed, front-wheel drive, three- and four-speed transmissions, pistons, piston pins, piston rings, valves, manifolds, and combustion chambers. Colonel Wall's paper was read at the recent meeting of the A.S.M.E. at French Lick, Ind.

Crane Lubrication

THE crane equipment of a large copper-refining plant had been responsible for undesirable delays in a period of increased production, and it was found upon examination that lubrication troubles were frequent causes therefor. How these were overcome is told by Eustis H. Thompson, lubrication engineer, Baltimore Copper Smelting & Rolling Co., Baltimore, Md., in a paper prepared for the A.S.M.E. Annual Meeting and printed in the December issue of MECHANICAL ENGINEERING. A plan of preventing losses due to lack of lubrication was worked out and is described by Mr. Thompson. He also describes the lubricants and lubricating devices, finally standardized. Engineers having the maintenance of large cranes as part of their duties will find Mr. Thompson's experiences of value to them.

The Quantum Theory

IN THE fourth and final instalment of Professor Wohlenberg's article on "Combustion Radiation and the Planck Quantum Theory," it is shown that the long discussions was necessary to prove that there is less than one chance in ten thousand that the radiation in a boiler furnace is not heat radiation, and therefore it is unnecessary to attempt any check-up on the disappearance of energy in any other form. Engineers are in the habit of dealing with particles at least as large as the molecule, and of studying mass effects. The analysis of the effects of microscopic particles such as individual quanta must be approached by way of mathematical methods where statistical mechanics are employed. It is gratifying to know that a study based upon modern conceptions of physical processes and the Planck quantum theory upholds the validity of the studies engineers have made of mass effects. Engineers should know more about statistical methods in the analysis of physical problems involving great numbers where probability plays such an important rôle.

Welding of Pressure Vessels

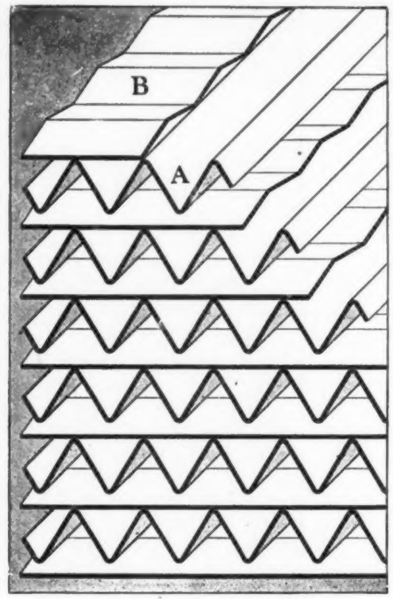
TWO items on the welding of pressure vessels appear in the December issue of MECHANICAL ENGINEERING. The first is the report of a test to destruction that was carried out on a superheater drum that had been electrically welded. The drum tested was similar to those being manufactured for use on one of the light cruisers for the United States Navy. The Bureau of Engineering of the Navy Department permits the use of hollow-forged drums and welded drums where the method of welding has been specifically approved and the efficiency of the welding will be guaranteed by tests. The results of the test of a superheater drum are given, and many illustrations show the drum before and after test and many details.

In this same issue will be found an official document known as Proposed Specifications for Fusion Welding of Unfired Pressure Vessels, prepared by the Boiler Code Committee of the A.S.M.E. The Specifications are proposed for embodiment in the Committee's Code for Unfired Pressure Vessels, and where additional requirements are given in these specifications over those for power boilers, they will be considered for inclusion in Specifications for Drums or Shells of Power Boilers. Discussion and suggestions are solicited from those interested.

Survey of Engineering Progress

ENGINEERING articles gleaned from the world's periodical literature and presented in abstract in the December issue of MECHANICAL ENGINEERING deal with the following subjects: The Argus aviation motor with suspended air-cooled cylinders; the "R-101" disaster; the Hesselman oil engine for motor vehicles; the "Kosfi-Leading" compensation induction motor with power-factor correction; the Gillett automatic clutch and free wheel; spark plugs; use of a boiler-feedwater heater with steam-powered rotary drilling equipment; a super-Lancashire boiler; a municipal Diesel plant at Hudson, Mass.; the Holmes locomotive poppet-valve gear; the Froelich hydraulic car-retarder system; a direct-expansion quick-freezing machine; the Carba solid-carbon-dioxide process; and calculation of oil temperatures of oil coolers.

EFFECTIVE HEATING SURFACE

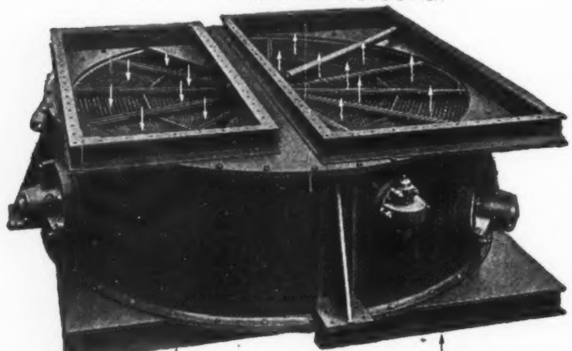


Ljungström Heating Surface

The new heating element differs from our former in that **undulating** partition sheets (B in the diagram) have been substituted for the former flat partition sheets. The undulations are in transverse direction to the vertical channels formed by the corrugations of the companion sheets A. Its superiority comes from the increased turbulence and wider penetration of flow, compelling the gas and air to strike **against** instead of merely **pass** over the metal surface. The heat transfer is accelerated to such a marked degree that a smaller volume of heating elements, which are shorter in length and have passages twice as large in cross-sectional area, will produce a given recovery.

THE highest heat recovery per dollar invested in air preheater equipment can be obtained with the Ljungström Preheater. This is due to the fact that the heating surface used is of more effective arrangement than that used in any other preheater on the market today. The effectiveness of this heating surface can be attributed to the arrangement of the heating elements, which provide for an intimate contact of the gas to be cooled and subsequently the air to be heated by breaking it up into small streams as it passes through the heating surface. In addition thereto, turbulent flow in each gas stream is obtained through the contact with the undulated surface on one side of each gas passage. Dead pockets for the accumulation of dust and ash which subsequently reduce the effectiveness of the heating surface as a whole are further avoided by the slowly turning rotor establishing a uniform flow of gas and air through every section of the heating surface as it passes through the gas and subsequently the air side of the heater. This high recovery is obtained at substantially less resistance or draft loss than with any other type of heater.

These facts were substantially demonstrated recently in the case of a large water works station, (Name on request) that purchased two preheaters to be installed in connection with two boilers of 1000-hp. rating each, in which the temperatures of the gases leaving the boilers varied between 370 and 525 deg. fahr. The Ljungström price was considerably lower than that of the lowest bidder on a recuperative type preheater and half that of another bidder, yet—the Ljungström guaranteed the greatest air temperature rise, the greatest gas temperature drop through the preheater, the lowest final exit temperature of flue gas, had greater free areas through both air and gas sides, and weighed only from one-third to one-sixth as much as the six recuperative outfits offered. The last item permits a tremendous saving in foundation and erection costs. As might be expected after an analysis of these advantages Ljungström Preheaters were purchased for this plant.

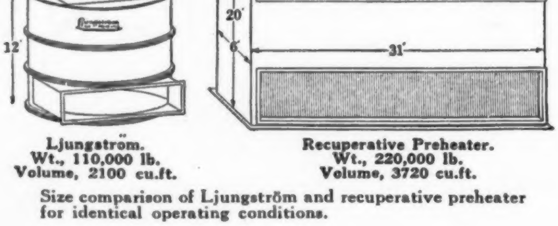


Type CNX, for use with independent forced-draft and induced-draft fans. All gas and air duct connections vertical. The most compact high efficiency air preheater ever offered. The over-all height is scarcely more than that of the rotor, and the external dimensions are so small that the preheater is virtually a negligible factor in figuring boiler-room space requirements.

Furnished in sizes for boiler units of up to 1000 hp.

Give us your plant data so that we can suggest attractive possibilities and refer you to Ljungström installations that have paid high returns under similar conditions.

Over 800,000 boiler hp. in service in the U. S. A.



Size comparison of Ljungström and recuperative preheater for identical operating conditions.

THE AIR PREHEATER CORPORATION

40 E. 34th St., New York

Works: Wellsville, N. Y.; Agents in

Boston	St. Louis	New Orleans	San Francisco
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Ljungström AIR PREHEATER
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CONTINUOUS REGENERATIVE COUNTERFLOW

FOR 1840 POUNDS W. S. P. PHILIP CAREY COMPANY ORDERS COPES

Among the plants Designed by W. E. S. DYER, *these plants are* COPES-Equipped

1925.........Union Paper Mills Co.
New Hope, Pennsylvania
W. S. P.—150 pounds

1925...Thomas Maddock's Sons Co.
Trenton, New Jersey
W. S. P.—200 pounds

1926...Aberfoyle Manufacturing Co.
Chester, Pennsylvania
W. S. P.—375 pounds

1928....Sunbury Converting Works
Sunbury, Pennsylvania
W. S. P.—350 pounds

1928........American Magnesia Co.
Plymouth Meeting, Pennsylvania
W. S. P.—350 pounds

1929............Ehret Magnesia Co.
Valley Forge, Pennsylvania
W. S. P.—200 pounds

1929....Restigouche Company, Ltd.
Beauly Siding, N. B., Canada
W. S. P.—340 pounds

1929....Sunbury Converting Works
Belvidere, New Jersey
W. S. P.—350 pounds

1929 Skenandoah Rayon Corporation
Utica, New York
W. S. P.—200 pounds

1930...............Philip Carey Co.
Lockland, Ohio
W. S. P.—1840 pounds

America's highest-pressure boilers . . . those of the Philip Carey Company, Lockland, Ohio . . . are to be equipped with COPES Feed Water Regulators. Again COPES pioneers for the feed water regulator industry!

America's highest-pressure plant is truly a pioneer. For the first time in American industrial history, reciprocating engines will be used with high-pressure boilers! The plant is designed by W. E. S. Dyer, consulting engineer of Philadelphia. He has ordered COPES . . . the pioneer feed water regulator . . . for the 1840-pound pressure boilers.

In 1920, COPES designed and built the first regulators for boilers operating at pressures greater than 1000 pounds. Two European installations were made. In 1928, COPES designed and built regulators for the first American 1400-pound pressure boilers at Edgar Station. In 1930, COPES is ordered for America's first 1840-pound pressure boilers.

High-pressure pioneers have faith in COPES . . . the pioneer feed water regulator. They know COPES gives instant, accurate response to changing load conditions . . . absolute dependability . . . tangible economy in boiler operation for the life of the boilers. Regardless of operating pressures.

May we present facts on the application of COPES to your boilers?

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COPES

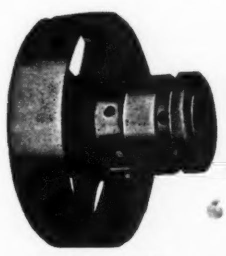
SYSTEM OF BOILER FEED CONTROL

THE JOHNSON FRICTION CLUTCH

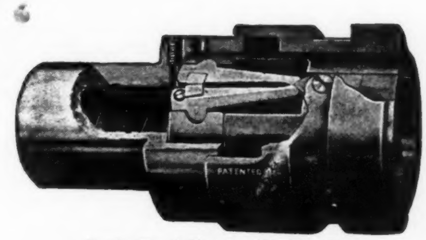
ONE POINT LUBRICATION,

ONE POINT ADJUSTMENT,

OF THIS SUPER—JOHNSON FRICTION CLUTCH



Single Clutch with Pulley



Single Clutch Showing Working Parts

No oil stained products, Lubrication stays inside.

Reliable Performance.

Adjustment won't slip or loosen, It LOCKS.

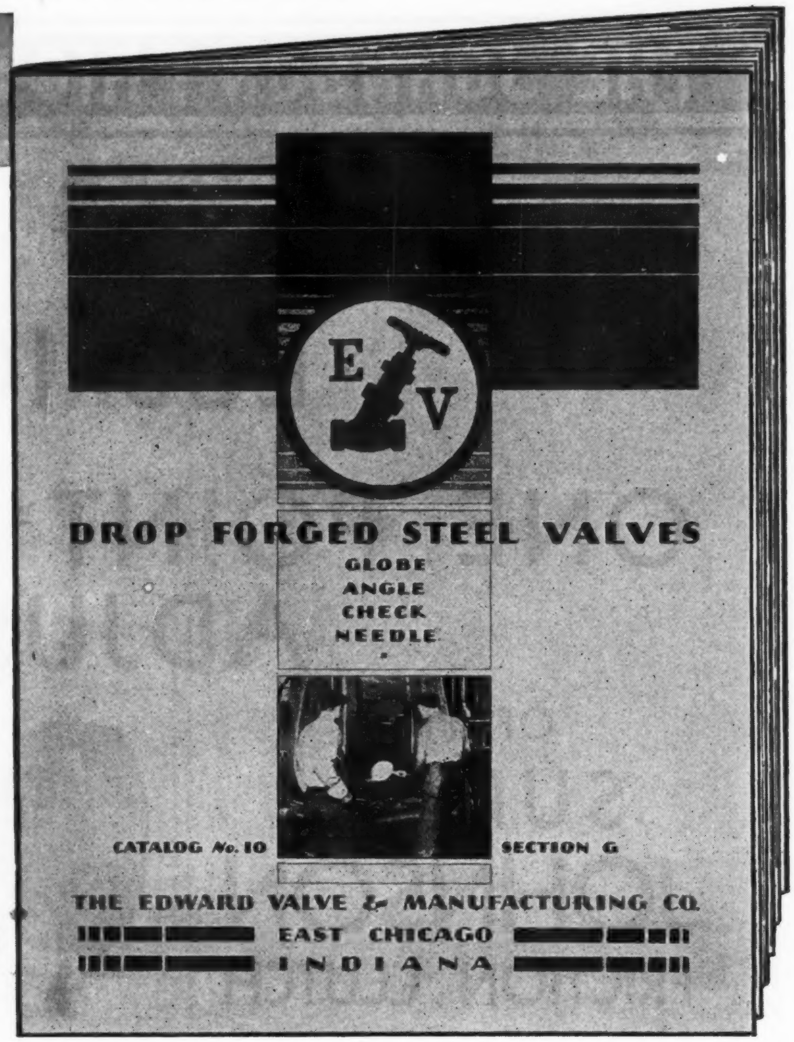
Double Clutch Between Bevel Gears

Double Clutch—Exterior

Wire, Phone or Write for Catalog "C-12"

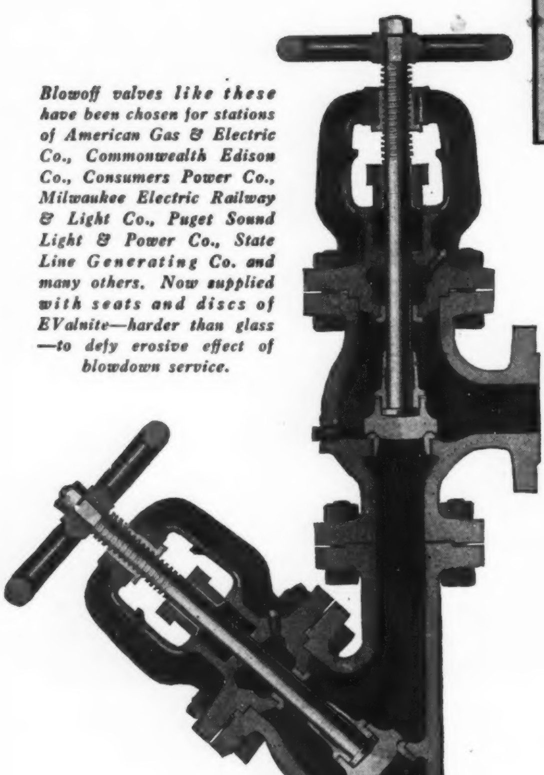
THE CARLYLE JOHNSON MACHINE CO. MANCHESTER CONN

Here's the new bulletin, 10G3, on Edward forged steel valves. If you are interested in better small valves, send for this comprehensive manual of globe and angle stops. Check valves, too. Also a new series for hydraulic service to 6000 lbs.



DOING ONE THING WELL

Blowoff valves like these have been chosen for stations of American Gas & Electric Co., Commonwealth Edison Co., Consumers Power Co., Milwaukee Electric Railway & Light Co., Puget Sound Light & Power Co., State Line Generating Co. and many others. Now supplied with seats and discs of EValnite—harder than glass—to defy erosive effect of blowdown service.



Spend all your days in intelligent study of one subject—and you're bound to learn a good deal about it. Edward builds only valves for high temperatures and pressures—at the lowest prices compatible with standards dictated by intimate knowledge of severe service requirements. The Edward shops form an interesting industrial museum of valve history in the making. They are always open to engineers and operators who desire to know *how quality is built into a valve.*

THE EDWARD VALVE & MANUFACTURING CO.
EAST CHICAGO - - - INDIANA

EDWARD VALVES

GARLOCK 7021

A Sheet Packing Developed to Meet the Severe Requirements of Oil Production and Refining Service

BUILT to withstand the extreme temperatures and pressures found in the modern refinery, Garlock-7021 sheet has met with universal success. It has been adopted as standard sheet packing in hundreds of refineries.

Garlock-7021 is a product which will stand up in service against hot oils and gasolines. Our files contain many reports of successful applications to heat exchangers, cracking stills, fractionating and bubble towers, wax presses, compressors, oil and gasoline pipe lines, gasoline storage tanks and, in fact, on every type and kind of producing and refining equipment. Garlock-7021 is furnished in all commercial thicknesses and in sheets 40" x 40" and larger. Gaskets cut from this sheet are styled Garlock-7022.

Without obligation on your part a Garlock Service Man will survey your entire operations and recommend suitable Garlock Packings and Gaskets for each requirement. We solicit the opportunity to co-operate with you.

THE GARLOCK PACKING COMPANY, Palmyra, New York. A World Wide Organization with Sales Offices and Warehouses in all Industrial Centers.

GARLOCK

Vol. I No. 9

High duty pump endurance depends on painstaking choice of Materials

by **W. L. CLAYPOOL,** ***Chief Engineer***

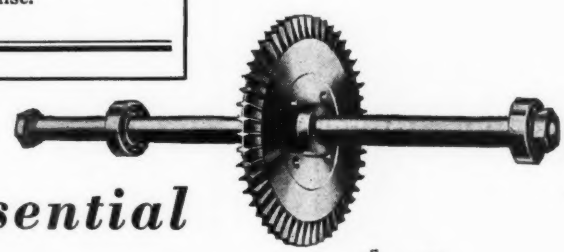
Westco-Chippewa Pump Co., Inc., Davenport, Iowa

This is No. 9 in a series of statements in which leading figures of the power industry stress the importance of Material—the 3rd Essential—in modern power plant equipment.

THE conscientious builder of modern, high duty pumping equipment must select material best suited for each part to supplement his ingenuity of design and perfection of workmanship. For the finished product of greatest durability will give a maximum of low-cost service to the user.

For instance, the shaft of a high speed turbine pump must have an unusual combination of metallurgical properties if it is to stand up under all of the conditions to which it will be subjected. (1) It must be strong and tough and stiff to carry the impeller at highest speeds without vibration. (2) It must have high fatigue value to resist fracture under such conditions. (3) It must be very rigid to avoid flexure that would cause eccentric deformation of the packing. (4) The surface must be capable of a highly lustrous polish to minimize friction at the glands.

Finally, the metal must be proof against rusting or pitting and immune to the greatest number of corrosive agents with which it may come in contact. This prolongs the life of the packing and insures continuous service with lowest maintenance expense.

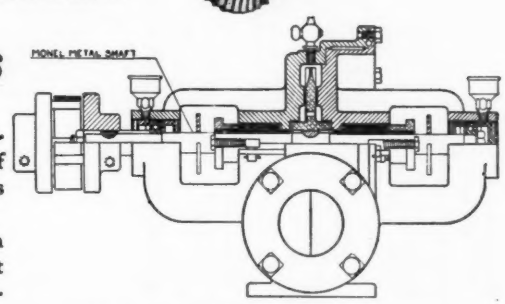


Monel Metal—the 3rd Essential in Westco Turbine pump shafts

Monel Metal shafts have been adopted as standard on Westco-Chippewa turbine pumps because this time-tested Nickel alloy possesses a combination of properties which is ideal for service where wide variations in temperatures and pressures prevail.

Since they are immune to rust and highly resistant to corrosion and erosion Monel Metal shafts have almost no tendency to pit or score, with the result that gland packing lasts longer and gives more efficient performance. Containing two-thirds Nickel, Monel Metal shafting has the strength and toughness of steel. It survives long periods of constant hard service, with minimum of repair expense.

It will pay you to bear in mind that "Nickel Alloys perform better longer" whenever the question of new power equipment arises.



Sketch showing sectional view of Westco Turbine Pump with Monel Metal impeller shaft mounted on ball bearings housed in brackets integral with pump body. Made by WESTCO-CHIPPEWA PUMP CO., Davenport, Iowa.

MONEL METAL

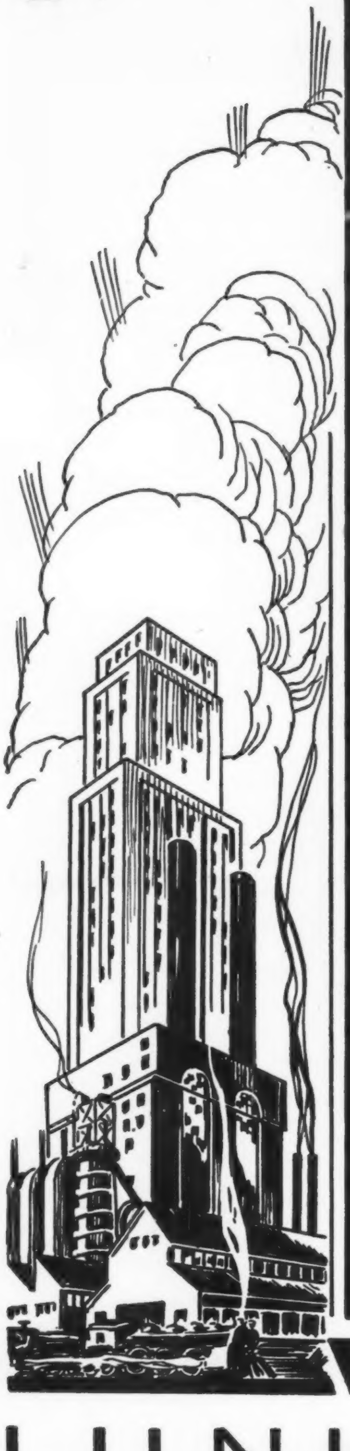
Monel Metal is a registered trade mark applied to a technically controlled nickel-copper alloy of high nickel content. Monel Metal is mined, smelted, refined, rolled and marketed solely by International Nickel.

INCO MONEL METAL

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

FOR BETTER SERVICE

in General Industry



LUNKENHEIMER STEEL VALVES

The Lunkenheimer Company has pioneered in the manufacture of steel valves.

Years of exhaustive research combined with the experience gained through active participation in the attainment of high pressure and temperature economies in the industrial and central station fields assure the maximum performance in Lunkenheimer Steel Valves demanded by present day valve users.

Procurable in a wide range of patterns and sizes for prevailing temperatures and pressures.

Lunkenheimer distributors are located in all industrial centers.

THE LUNKENHEIMER CO.
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LUNKENHEIMER VALVES

15-51-4

The NITRA

The Ashcroft American DURAGAUGE is made in sizes from 4½" to 16", for all pressures up to 5,000 lbs., in Wall Mounted case, Flush Mounted, and Flush Mounted Illuminated cases for gauge boards.

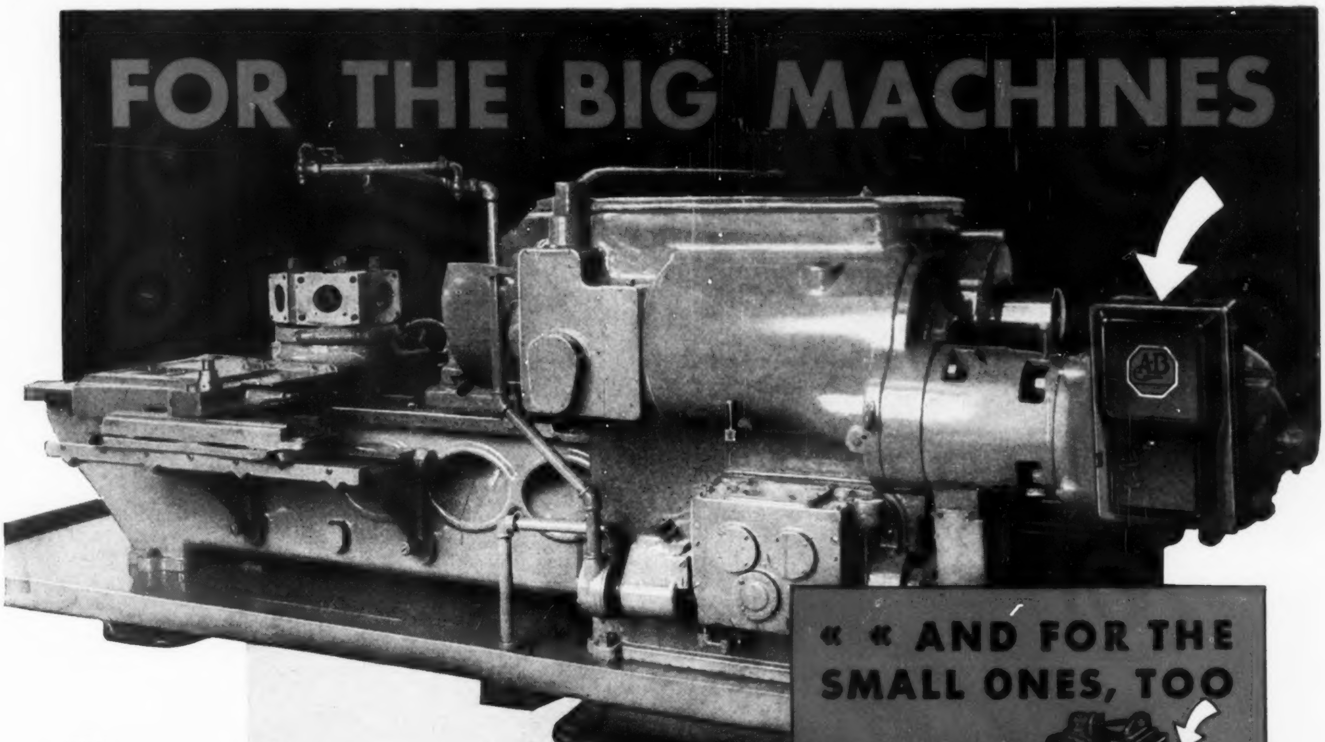
SIX months ago the nitralloy movement of one of our new Ashcroft American DURAGAUGES was connected to a small compressed air hammer vibrating at about 1500 cycles per minute. At the same time the movement of a commercial gauge was attached to the same hammer in the same way.

The hammer has been vibrating 24 hours a day ever since. The nitralloy movement still shows no sign of wear, but the other gauge movement has been replaced suc-

CONSOLIDATED ASHCROFT HANCOCK

American Dial Thermometers	G-24	American Temperature Controllers	R-24
American Glass Thermometers	F-24	American Recording Gauges	E-24
American Recording Thermometers	H-24	American Draft Gauges	B-24
Ashcroft American Gauges	A-24	American Gauge Testers	D-24

Specify Catalogs Desired



There is an Allen-Bradley Control that exactly fits the Job

Bulletin 709-710 A. C. Push Button Starters with overload relays.

Bulletin 609 A.C. Hand operated Starter with overload breakers.

Bulletin 265 D.C. Push Button Starter with overload relays.

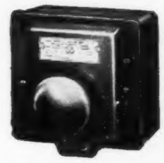
THE Allen-Bradley Line makes a mighty powerful appeal to manufacturers of motorized machines!

Why? Because the Allen-Bradley Line is practically a universal line. There is a standard starter for every type of service.

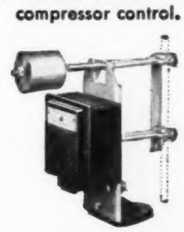
Do you need standard starters, dust-proof starters, moisture-proof starters, explosion-proof starters, manual starters, or any one of 200 accessories for motor control? Then investigate the Allen-Bradley Line. No matter what your control problems are, *there is an Allen-Bradley Control that fits the job.*

Write for bulletins or consult the nearest Allen-Bradley office.

Allen-Bradley Co., 1319 S. First St., Milwaukee, Wis.



Bulletin 830 Automatic Pressure Switch for compressor control.



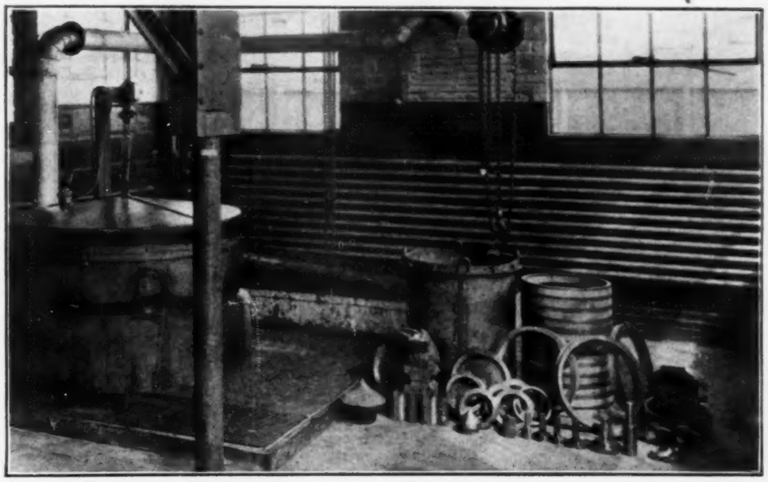
Bulletin 840 Automatic Float Switch for pump control.

There is an Allen-Bradley Control Station for every application.

Allen-Bradley

A-B

Manual and Automatic Starters



Nitriding Furnace Installed in Walworth Shops and at Right, Valve Parts Ready for Nitriding

Specify

WALWORTH
VALVES
FITTINGS
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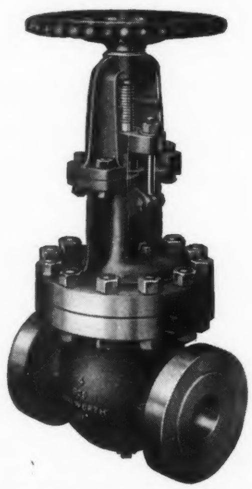
for

POWER



Series 900 Plain Yoke
O. S. & Y. Wedge Gate

WALWORTH OFFERS SIGMA STEEL VALVES WITH NITRALLOY TRIM

• Walworth Sigma Steel valves for high pressure, high temperature steam service are now available with Nitralloy seat rings and discs forgings. • These trim materials, processed in Walworth shops, are especially recommended for steam service at 750° F. and higher.

• Nitralloy is a Krupp's patented alloy steel which, when exposed to ammonia gas at high temperature, develops an exceedingly high surface hardness, which is well maintained at advanced working temperatures. • Walworth Company has installed its own processing plant for nitriding and to this Nitralloy trim we have assigned the trade name Sigmalloy 352.

• Walworth Catalog 88 contains a complete Walworth Sigma Steel recommendation chart covering working pressures and temperatures. • You can have a reprint of this chart for handy desk use on request to our Engineering Products Division.

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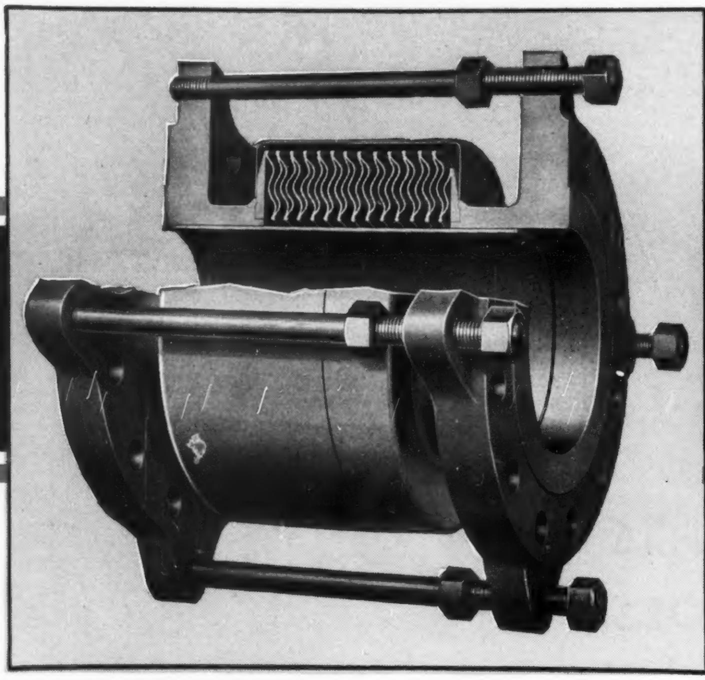
CROLL-REYNOLDS

DO NOT LEAK



DO NOT BREAK

FlexoDisc Expansion Joints

The FlexoDisc is an entirely new type of expansion joint which permits free movement of the piping without strain through the use of a flexible steel expansion element.

OUTSTANDING FEATURES

ELASTIC MOVEMENT

The movement of the flexible element is analogous to that of a steel spring, the maximum stresses being always sufficiently within the elastic limit so that the element will take an unlimited number of movements without failure.

ELEMENT PLATES OF NICKEL STEEL

A tough dependable material developing unusually high elastic strength under heat treatment. This alloy is non-corrosive compared to ordinary steel but stainless steel is furnished where unusual corrosion conditions exist.

G. E. ATOMIC HYDROGEN WELDING

Producing a perfect homogeneous weld by fusing together the edges of the plates in a non-oxidizing atmosphere.

COMPLETE ELEMENT HEAT TREATED

To secure maximum elastic strength, uniform quality, and freedom from all local stresses due to welding.

GUIDED MOVEMENT

By means of an internal sleeve—of brass or steel for ordinary conditions—of **MONEL METAL** for superheated steam or other severe service.

This construction eliminates packing, leaks, enforced shutdowns, repairs and all other maintenance work, yet lasts for many years and requires but little space in the piping system.

FlexoDisc Expansion Joints effectively take care of expansion in all steam, air, water, gas, oil or other pipe lines handling hot fluids. For complete information write for Bulletin M-40.

This apparatus is manufactured under the RAY Patents issued and pending

Croll-Reynolds Engineering Co., Inc. **New York, N. Y.**

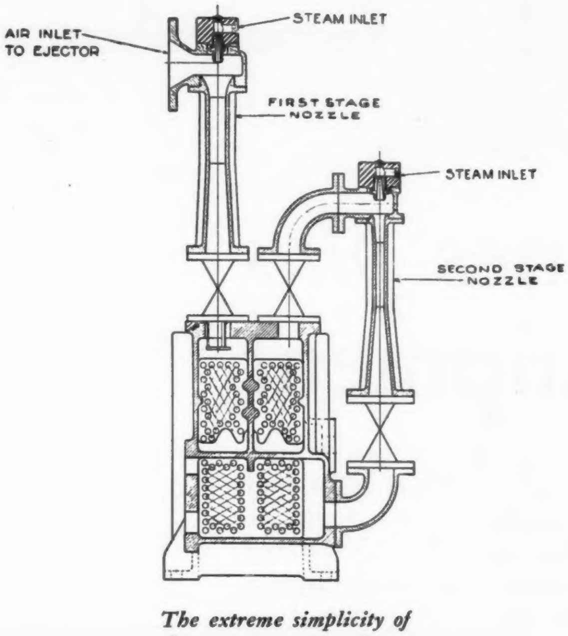
Representatives in Principal Cities

As Simple as a Pipe Fitting

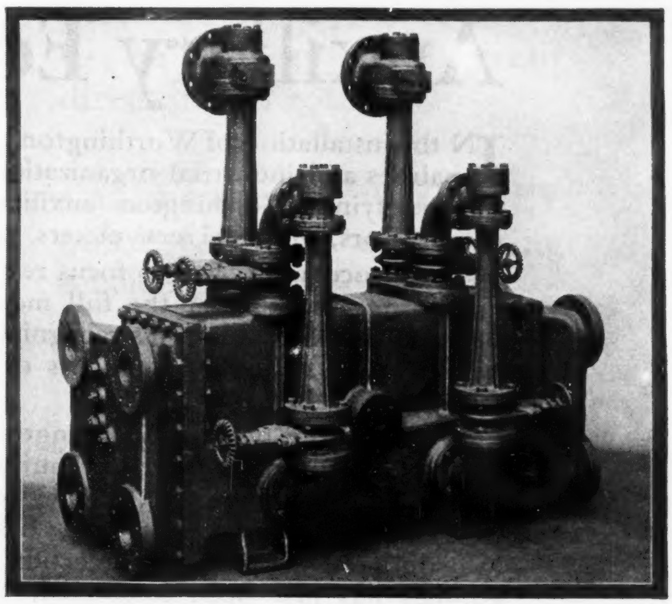
... NO MOVING PARTS

Beginning with the pioneering of high-vacuum apparatus on this continent, Westinghouse has constantly improved the design and application of the various types of this equipment until today the Westinghouse Air Ejector has become the recognized standard for such apparatus.

One of the outstanding features of Westinghouse Air Ejectors is their unusual simplicity—a factor that has established the utmost reliability and efficiency in their performance.



The extreme simplicity of the two-stage air ejector is illustrated by this cross-section.



Two two-stage air ejectors mounted on intermediate and after condensers.

Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops

Westinghouse

WESTINGHOUSE ELECTRIC

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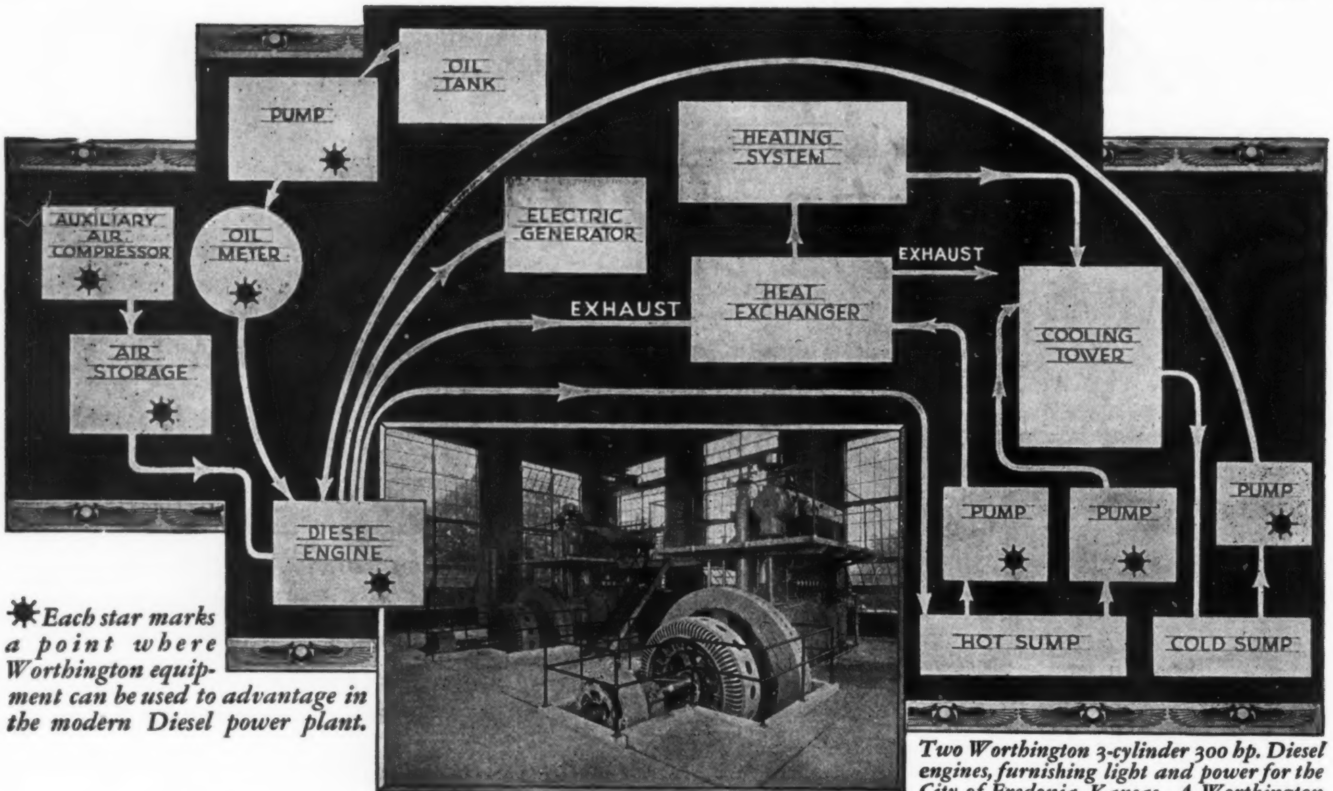
TUNE IN THE WESTINGHOUSE SALUTE OVER THE N. B. C. NATION-WIDE NETWORK EVERY TUESDAY EVENING.



Each star marks a point where Worthington equipment can be used to advantage in the modern Diesel power plant.

Two Worthington 3-cylinder 300 hp. Diesel engines, furnishing light and power for the City of Fredonia, Kansas. A Worthington 6-cylinder 600 hp. engine has been added to this plant.

Diesel Engines *plus* Auxiliary Equipment

IN the installation of Worthington Diesel power plants, municipalities and industrial organizations find a distinct advantage in specifying Worthington auxiliary equipment as well . . . compressors, air receivers, meters, pumps and Multi-V-Drives.

This procedure serves to focus responsibility on Worthington, and brings to the user the full measure of benefit from Worthington's recognized engineering skill and high standards of manufacture.

Write to the nearest Worthington office for information on the type of equipment in which you are interested. A new 48-page illustrated bulletin, S-500-B2A, describing Worthington vertical air-injection Diesel engines has just been completed. *May we send you a copy?*

PUMPS	GAS ENGINES
COMPRESSORS *Stationary and Portable*	DIESEL ENGINES
CONDENSERS and Auxiliaries	WATER, OIL and GASOLINE METERS
FEEDWATER HEATERS	MULTI-V-DRIVES
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WORTHINGTON

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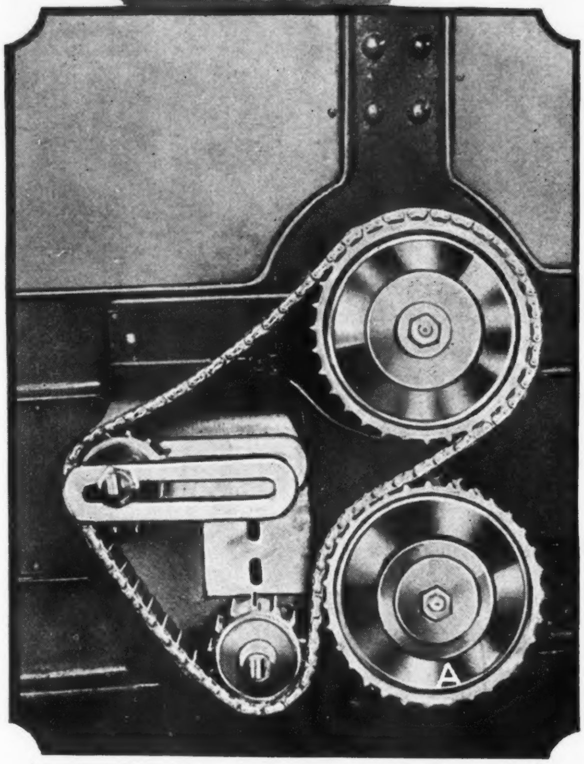
Reverse Drive

on Wool Spinning Frame



THE WHITNEY reversible type chain illustrated here is desirable wherever there are a number of shafts to be driven in different directions of rotation.

Call the nearest WHITNEY office for free engineering service.

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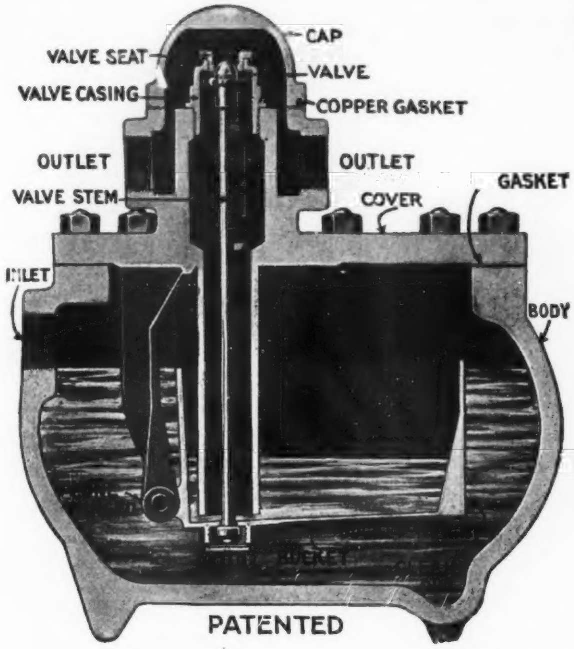
THE WHITNEY MFG. CO., Hartford, Conn.

WHITNEY SILENT CHAIN DRIVES



Modern steam economy demands the unfailing service given by the Standard Genuine SQUIRES Steam Trap

A brief study of this trap and its mechanism quickly shows why it is ordered and re-ordered by leading power plants.

Valves and seats are of the best metal obtainable, easily accessible without breaking any pipe connections. The standard valve mechanism is used for ordinary service and the double mechanism for heavy condensation.

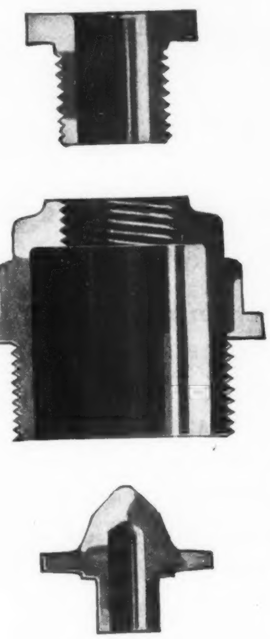
Without attention or repairs, Squires Traps give intermittent discharge through a wide-open valve that acts positively to a wide-open or tight-shut position.

As all joints are above the water line, the valve mechanism is not affected by unequal expansion and contraction or corrosion.

Where safety of equipment and quality of product are essential you can depend on perfect drainage from steam pipes, steam separators, heaters, coils, stills, receivers, etc.

Not only are Squires Traps distinguished for their leakproof, dependable service over many years regardless of severe conditions, but they save the day when large slugs of water are carried over into the pipe lines with their quick valve action and large capacity.

Send for Catalogue "H-90" for a full survey of Squires Traps and how they will save steam, money, repairs and replacements in your trapping service of all kinds—low and high pressure, vacuum, air, gasoline, etc.



At left, Standard Valve Mechanism for the Standard Genuine Squires Steam Trap. Furnished for all pressure ranges.

Above, Double Valve Mechanism. These are interchangeable by changing caps.

Other Squires Specialties:

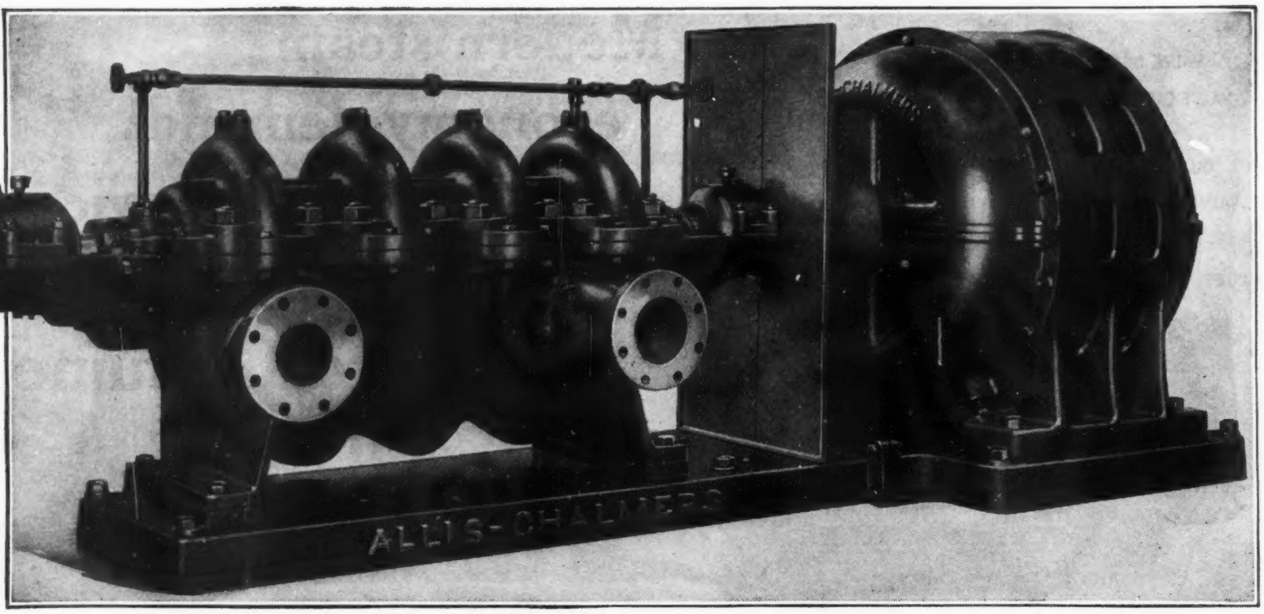
New Genuine Squires Steel Trap
Reducing Valve
Class "E" Pump Governor
Class "H" Pump Governor
Class "B" Excess Pump Governor
Boiler Feed Water Controller

Insist on the Genuine Squires

TRADE MARK

Steam Specialties

The C.E. Squires Company E. 40th St. & Kelley Ave., Cleveland


ALLIS-CHALMERS

Accuracy in handling
MULTIPLIES MACHINE PRODUCTION

. . . Accuracy in handling demands the hoist precisely suited to the job.

WHAT space must be served? How great is the headroom? What is the average load? How many times, how fast and high must the load be lifted? These are some of the questions that must be answered—and the answer satisfied by the hoist which is selected—to provide the maximum economy in handling.

Obviously, a few types and sizes cannot satisfy the great variety of services which modern industry presents. That is why Shepard builds electric hoists in such a comprehensive variety of types, in many capacities, and with the proper control for every need. Unit construction, from standard interchangeable parts, makes every Shepard a performance-proved machine. Shepard's "Balanced" drive invariably functions smoothly—alignment is permanent—control is positive. Automatic oil bath lubrication minimizes wear.

Industry is effecting striking economies through overhead handling, planned with the aid of the Shepard Electric Hoist precisely suited to the service. Some typical results are given in the booklet "Illustrated Economies." Write for a copy!

SHEPARD NILES CRANE & HOIST CORP.
Main Office 370 Schuyler Ave., Montour Falls, N.Y.
Works: Montour Falls, N.Y., and Philadelphia, Pa.
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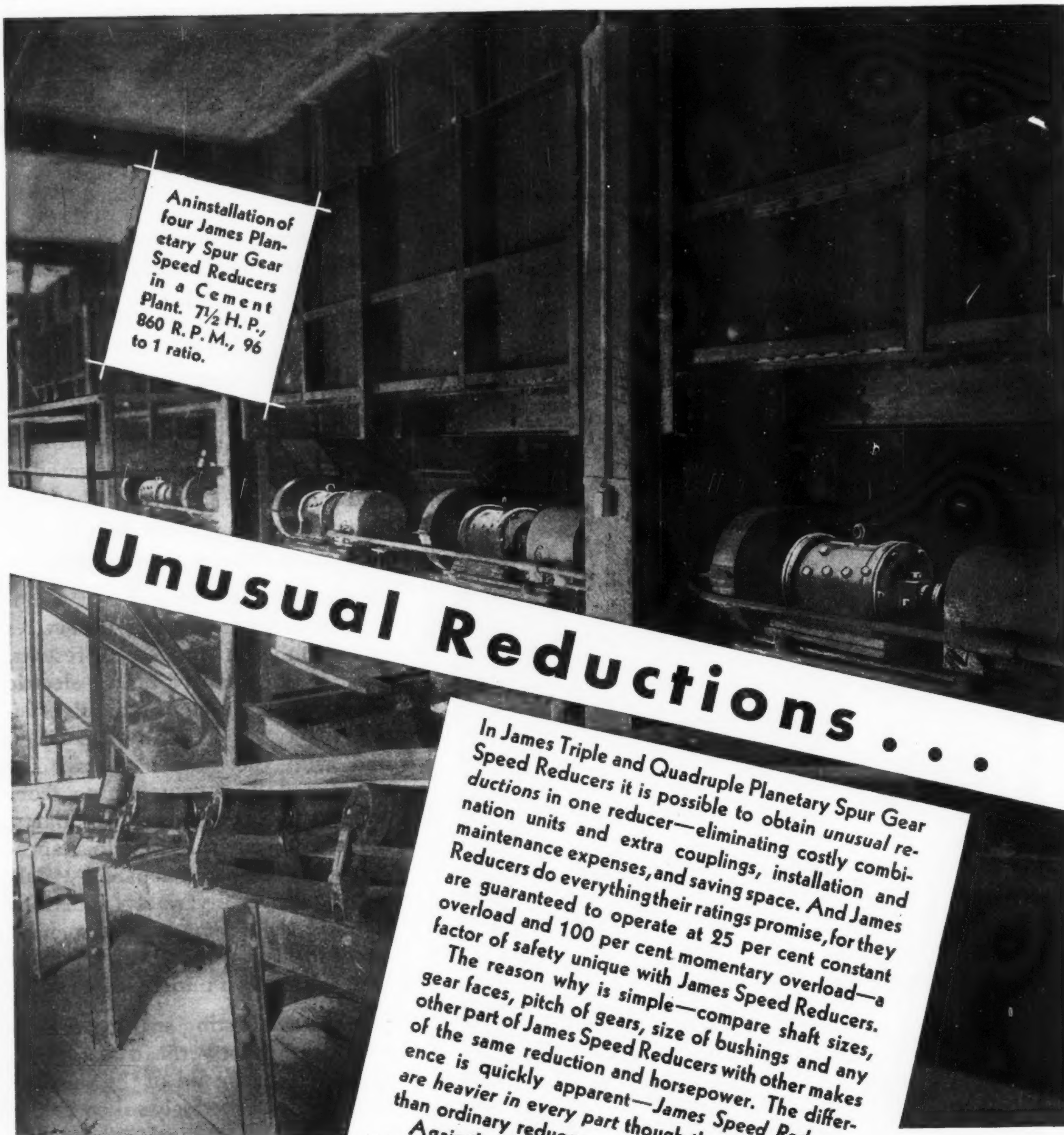
THE MOST COMPLETE LINE OF CRANES & HOISTS IN AMERICA



Unusual Reductions . . .

In James Triple and Quadruple Planetary Spur Gear Speed Reducers it is possible to obtain *unusual reductions* in one reducer—eliminating costly combination units and extra couplings, installation and maintenance expenses, and saving space. And James Reducers do everything their ratings promise, for they are guaranteed to operate at 25 per cent constant overload and 100 per cent momentary overload—a factor of safety unique with James Speed Reducers.

The reason why is simple—compare shaft sizes, gear faces, pitch of gears, size of bushings and any other part of James Speed Reducers with other makes of the same reduction and horsepower. The difference is quickly apparent—*James Speed Reducers are heavier in every part* though they cost no more than ordinary reducers.

Again the reason why is simple—high production. More James Speed Reducers are in service today than any other make and more are being sold, for Industry demands proved equipment—the correct machine for each job and guaranteed performance.

Regardless of your speed reducer problems, there is a James Reducer to solve each problem properly, even the most *unusual reductions*. Send for descriptive catalog and list of standard types and sizes. Catalog No. 166 sent free on request.

D. O. JAMES MANUFACTURING CO.
1120 West Monroe Street, Chicago
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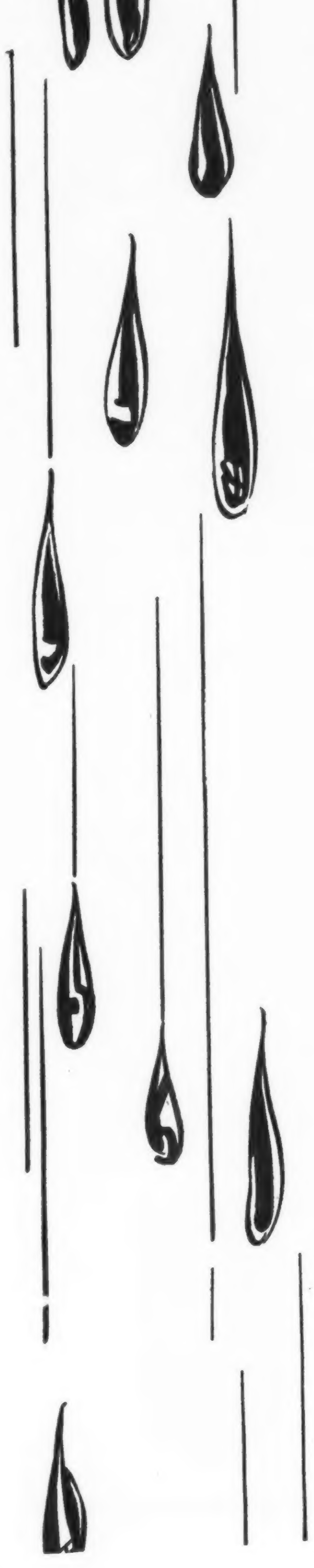
Come to Headquarters!

Make us your headquarters for cut gears and speed reducers. Our unequaled facilities and enormous stocks of finished speed reducer parts allow for quick shipment of many sizes. Only James makes all types of speed reducing units—the correct machine for every drive.



LOOK OUT BELOW!

DROPS of moisture condensed at the ceiling never shout a warning. But they often cause damage below. Silently they collect. They rust machinery, ruin materials, and cause millions of dollars of damage and loss each year.

Adequate Insulation Necessary

Wise executives are protecting their buildings from this costly depreciation by insulating roofs with Armstrong's Corkboard Insulation. And they are annually saving millions in fuel bills, too, because Armstrong's Corkboard provides efficient insulation—shuts out summer heat, winter cold. Now, year 'round comfort is brought to *every* floor.

Easily Applied

Armstrong's Corkboard can be laid over any type of roof-deck—old or new. It is moisture-resistant. It does not buckle, shrink, or swell. And it can be laid quickly, because it comes in a *single thickness*!

We suggest that you write for a copy of the book, "The Insulation of Roofs with Armstrong's Corkboard." It contains much valuable information about insulating every type of roof. Armstrong Cork & Insulation Company, 911 Concord Street, Lancaster, Pennsylvania.

Armstrong's (A) Product

Armstrong's Corkboard Insulation

FOR THE ROOF OF EVERY BUILDING


DAVIS VALVE SPECIALTIES for automatic-pressure and flow control
Pressure Regulator
Reduces boiler pressure to the correct low pressure desired, and maintains it automatically and dependably.
Steel valves for high pressure, high temperature services are trimmed with
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A simple, single-seated valve for controlling liquid levels in open tanks or reservoirs. No leaking or sticking.
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For every service requiring a valve unaffected by the internal pressure. Operated by some force exerted on the lever.
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Automatically prevents a reverse flow from header to boiler. Protected from scale formation and expansion. Can be hand tested. Visible action.
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Holds tight under high condenser vacuum, relieves to the atmosphere at a fraction of a pound pressure. Maintenance negligible.
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The original semi-balanced valve for maintaining an exhaust back pressure. Will not stick or leak.
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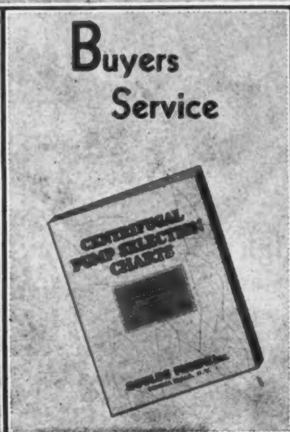
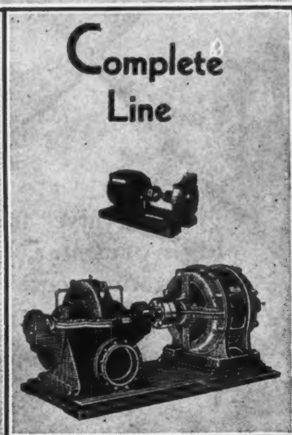
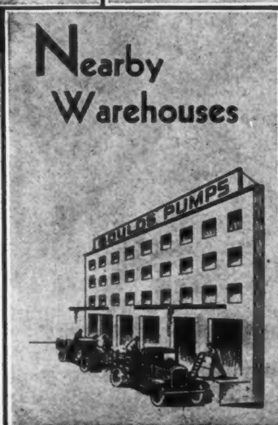
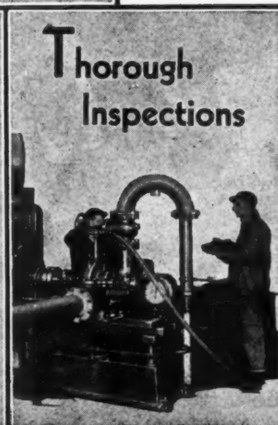
What Goulds Service Means to You









WHAT Goulds service really means is this: That whatever your pumping requirements may be, there is a Goulds pump to fulfill them. That wherever you may be, there is a complete stock of Goulds pumps near you, and there is a Goulds representative close at hand, always ready to give you expert assistance.

Hundreds of industrial plants are benefiting by the economical operation of Goulds pumps, and by their absolute dependability, both in every-day service and in emergencies. The efficiency and dependability of these pumps are the direct result of 82 years of pump making.

In a word, the complete facilities of the world's largest plant devoted exclusively to the manufacture of pumps are available to industry in the solution of pumping problems. You can obtain these services simply by calling the Goulds representative in your city, or writing the nearest branch office or the main office.

GOULDS PUMPS, Inc., Seneca Falls, N.Y.

BRANCHES:

*BOSTON
194 Congress Street
*CHICAGO
12-14 So. Clinton Street
HOUSTON
1902 Second National Bank Bldg.
*NEW YORK
16 Murray Street
19 Park Place
PITTSBURGH
636 Henry W. Oliver Building
*TULSA
213 E. Archer Street
*PHILADELPHIA
111 North Third Street
ATLANTA
Citizens and Southern Bank Bldg.
CLEVELAND
Union Trust Building
*Branch Warehouses

Representatives in all Principal Cities

GOULDS PUMPS

Buyers Index to Products Manufactured by Advertisers

CLASSIFIED LIST OF MECHANICAL EQUIPMENT

For Alphabetical List of Advertisers See Page 172

Continued on Pages 38, 40, 42, 44, 46, 48 50, 52 and 54

Accumulators (Hydraulic)
* Farrel-Birmingham Co. (Inc.)

Aftercoolers (Air)
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Pennsylvania Pump & Compressor Co.
* Sullivan Machinery Co.

Air Conditioning Apparatus
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Sturtevant, B. F., Co.

Air Cooled Bottoms for Powdered Fuel Furnaces
* Allen-Sherman-Hoff Co.

Air Washers
* Badger, E. B., & Sons Co.
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Sturtevant, B. F., Co.

Alloys
* Aluminum Co. of America
* Parker Appliance Co.

Aluminum
* Aluminum Co. of America

Ammeters
* Bristol Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Anemometers
Weber, F., Co. (Inc.)

Annealing
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Arches (Boiler Furnace)
* Combustion Engrg. Corp'n
* McLeod & Henry Co.

Asbestos Products
* Garlock Packing Co.

Ash Handling Systems
* Allen-Sherman-Hoff Co.
* Combustion Engrg. Corp'n
* Link-Belt Co.

Ash Hoppers (Cast Iron)
* Allen-Sherman-Hoff Co.

Ash Removal Systems
* Allen-Sherman-Hoff Co.

Ash Storage Tanks (Cast Iron)
* Allen-Sherman-Hoff Co.

Babbitt Metal
* Reeves Pulley Co.

Balls (Brass and Bronze)
* Gwilliam Co.

Balls (Cast Iron, Chilled)
* Fuller Lehigh Co.

Balls (Steel)
* Gwilliam Co.
* New Departure Mfg. Co.

Barometers
* Consolidated Ashcroft Hancock Co. (Inc.)

Barrels (Shop)
* Breese Bros. Co.

Barrels (Tumbling)
* Farrel-Birmingham Co. (Inc.)

Bars (Aluminum)
* Aluminum Co. of America

Bearings (Ball)
* Fafnir Bearing Co.
* Gwilliam Co.
* New Departure Mfg. Co.
* Norma-HoffmannBearingsCorp'n
* Strom Bearings Co.

Bearings (Roller)
* Gwilliam Co.
* Norma-HoffmannBearingsCorp'n
* Reeves Pulley Co.
Rollway Bearing Co. (Inc.)
* Timken Roller Bearing Co.

Bearings (Self-Oiling)
* Farrel-Birmingham Co. (Inc.)
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
Wood's, T. B., Sons Co.

Bearings (Tapered Roller)
* Timken Roller Bearing Co.

Bearings (Thrust)
* Fafnir Bearing Co.
* General Electric Co.
* Gwilliam Co.
* New Departure Mfg. Co.
* Norma-HoffmannBearingsCorp'n
Rollway Bearing Co. (Inc.)
* Strom Bearings Co.
* Timken Roller Bearing Co.

Belt Dressing
* Alexander Bros. (Inc.)
Chicago Rawhide Mfg. Co.
* Dixon, Joseph, Crucible Co.

Belt Lacing (Steel)
* Bristol Co.
Chicago Rawhide Mfg. Co.

Belt Tighteners
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Smidth, F. L., & Co.
Wood's, T. B., Sons Co.

Belting (Conveyor, Transmission)
* Alexander Bros. (Inc.)
Chicago Rawhide Mfg. Co.
Goodrich, B. F., Rubber Co.

Belting (Leather)
* Alexander Bros. (Inc.)

Benders (Tube)
* Parker Appliance Co.

Bending Machines (Hand)
* Parker Appliance Co.

Bench Legs
* Lupton's, David, Sons Co.

Bending and Straightening Machines
* Farrel-Birmingham Co. (Inc.)

Billets (Steel)
Stanley Elect. Tool Co.
* Timken Roller Bearing Co.

Bins and Shelving (Steel)
* Breese Bros. Co.

Blocks (Cork)
* Armstrong Cork & Insulation Co.

Blocks (Pillow)
* Farrel-Birmingham Co. (Inc.)
Rollway Bearing Co. (Inc.)

Blowers (Centrifugal)
* Buffalo Forge Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Blowers (Fan)
* Buffalo Forge Co.
* Century Electric Co.
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Blowers (Pressure)
* Buffalo Forge Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Sturtevant, B. F., Co.

Blowers (Steam Jet)
* Schutte & Koerting Co.

Blowers (Turbine)
* Buffalo Forge Co.
* De Laval Steam Turbine Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Blueing (Metal)
* American Metal Treatment Co.

Board (Cork)
* Armstrong Cork & Insulation Co

Boards, Drawing
Weber, F., Co. (Inc.)

Boiler Baffles
* Babcock & Wilcox Co.
* McLeod & Henry Co.

Boiler Compounds
Dearborn Chemical Co.
* Dixon, Joseph, Crucible Co.

Boiler Feed Water Treatment
Dearborn Chemical Co.

Boiler Fronts
* Babcock & Wilcox Co.
* Erie City Iron Works

Boiler Furnace Construction
* Erie City Iron Works
* Fuller Lehigh Co.

Boiler Settings (Steel Cased)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* McLeod & Henry Co.
* Vogt, Henry, Machine Co.

Boilers (Heating)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works

Boilers (Locomotive)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works

Boilers (Marine, Scotch)
* Combustion Engrg. Corp'n
* Erie City Iron Works

Boilers (Marine, Water Tube)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Connelly, D., Boiler Co.
* Erie City Iron Works
* Springfield Boiler Co.

Boilers (Portable)
* Combustion Engrg. Corp'n
* Erie City Iron Works
Frick Co. (Inc.)
* Keeler, E., Co.
* Union Iron Works

Boilers (Tubular, Horizontal Return)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Connelly, D., Boiler Co.
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Tubular, Vertical Fire)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works

Boilers (Waste Heat)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Wickes Boiler Co.

Boilers (Water Tube, Horizontal)
* Babcock & Wilcox Co.
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Connelly, D., Boiler Co.
* Erie City Iron Works
* Keeler, E., Co.
* Springfield Boiler Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Water Tube, Inclined)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Water Tube, Vertical)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works
* Wickes Boiler Co.

Boxes (Journal)
* Farrel-Birmingham Co. (Inc.)
Rollway Bearing Co. (Inc.)

Boxes (Shelf, Shop, Tote)
* Breese Bros. Co.

Boxes (Tool, Tote)
* Lupton's, David, Sons Co.

Brackets (Pipe)
* Grinnell Co.

Breechings (Smoke)
* Combustion Engrg. Corp'n
* Vogt, Henry, Machine Co.

Brick (Cork)
* Armstrong Cork & Insulation Co.

Brick (Fire)
* Bernitz Furnace Appliance Co.
* Botfield Refractories Co.
* Lavino, E. J., & Co.
* McLeod & Henry Co.

Brick (Insulating)
* Armstrong Cork & Insulation Co.

Bridgewalls (Furnace)
* McLeod & Henry Co.

Broaching Machines (Hydraulic)
Oilgear Company

Buckets (Elevator)
* Breese Bros. Co.
* Link-Belt Co.

Bunkers (Coal and Ash)
* Allen-Sherman-Hoff Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n

Burners (Gas and Oil Combined)
* Coen Co. (Inc.)
* Peabody Engrg. Corp'n

Burners (Oil)
* Bethlehem Steel Co.
* Coen Co. (Inc.)
* Combustion Engrg. Corp'n
* Peabody Engrg. Corp'n
* Schutte & Koerting Co.

Burners (Powdered Fuel)
* Coen Co. (Inc.)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Peabody Engrg. Corp'n
* Riley Stoker Corp'n

Burners (Powdered Fuel, Oil and Gas Combined)
* Coen Co. (Inc.)

Bushings (Bronze)
Wood, T. B., Sons Co.

Cabinets (Blue Print Filing)
Weber, F., Co. (Inc.)

Calcium Carbide
* Union Carbide Sales Co.

Calorimeters
* Consolidated Ashcroft Hancock Co. (Inc.)

Cams
* Hartford Special Machinery Co.

Cans (Oily Waste and Paper)
Nugent, Wm. W., & Co. (Inc.)

Casehardening
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Casings (Steel, Boiler)
* Combustion Engrg. Corp'n
* Vogt, Henry, Machine Co.

Castings (Acid Resistant)
* Bethlehem Steel Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fuller Lehigh Co.
Walworth Co.

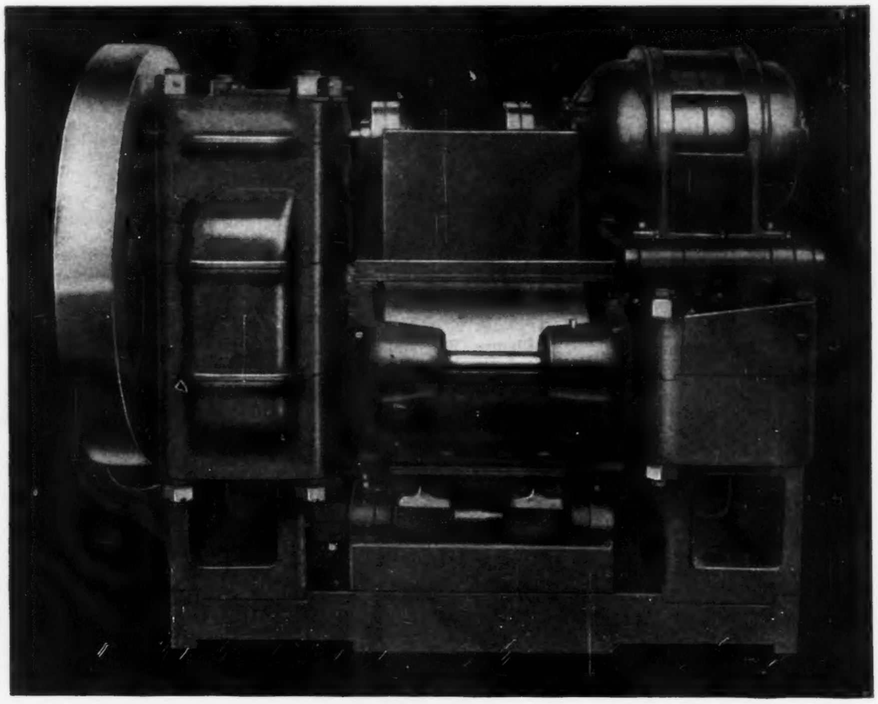
Castings (Aluminum)
* Aluminum Co. of America
Wood's, T. B., Sons Co.

Castings (Aluminum, Die Cast)
* Parker Appliance Co.

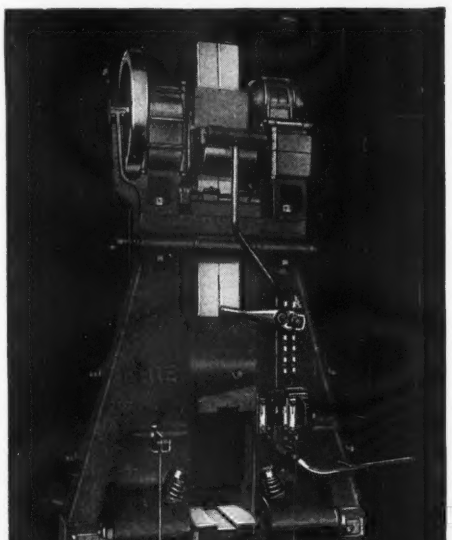
Castings (Brass)
* Bethlehem Steel Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Machy. Co.
* Edward Valve & Mfg. Co.
* Parker Appliance Co.
Walworth Co.

Castings (Bronze)
* Bethlehem Steel Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*



NEW DEPARTURE BALL BEARINGS



Comparison finds them superior

When a progressive drop hammer builder goes to the expense of trying and testing the various types of bearings for *the one* which will best serve its very rigid requirements . . . you can bet that performance, and not prejudice, will decide the issue. The Erie Foundry Company has tested them all, and here's why New Departure Ball Bearings were chosen for all shafts in their motor-driven hammer:

- **Because they start easier and run smoother, save power.**
- **Because they prevent wear more effectively, hence eliminate those misalignments which seriously affect proper hammer operation.**
- **Because they need less attention than any other type . . . fewer relubrications, no adjustments.**
- **Because any side strains are easily taken care of, by their generous thrust capacity.**
- **Because they generally outlast any machine into which they are properly installed.**

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1930-31 EDITION

You can buy New Departures in a thousand cities. The name of your local distributor upon request. Engineering consultation service without obligation at The New Departure Mfg. Company, Bristol, Connecticut.

NOTHING ROLLS LIKE A BALL

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

* Economy Pumping Machy. Co.
Walworth Co.
Wood's, T. B., Sons Co.

Castings (Die-Molded)
* Aluminum Co. of America
* Veeder-Root (Inc.)

Castings (Heavy)
* Aluminum Co. of America
* Bethlehem Steel Co.
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
Poole Engrg. & Machine Co.

Castings (Iron)
* Bethelehem Steel Co.
* Builders Iron Foundry
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Croll-Reynolds Engineering Co.
* Economy Pumping Machy. Co.
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
* Garlock Packing Co.
* Jones, W. A., Fdry. & Mach. Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Vogt, Henry, Machine Co.
Wood's, T. B., Sons Co.

Castings (Iron, Chilled)
* Fuller Lehigh Co.

Castings (Monel Metal)
* International Nickel Co. (Inc.)

Castings (Nickel)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Farrel-Birmingham Co. (Inc.)
* International Nickel Co. (Inc.)

Castings (Semi-Steel)
* Builders Iron Foundry
* Croll-Reynolds Engrg. Co. (Inc.)
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Vogt, Henry, Machine Co.
Walworth Co.
Wood's, T. B., Sons Co.

Castings (Steel)
* Bethelehem Steel Co.
* Falk Corporation
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
Reading Steel Casting Co. (Inc.)
* Springfield Boiler Co.
Walworth Co.

Cement (Asbestos)
* Armstrong Cork & Insulation Co.
Walworth Co.

Cement (Insulating Heat)
* Armstrong Cork & Insulation Co.

Cement (Iron and Steel)
Smooth-On Mfg. Co.

Cement (Pipe Joint)
Smooth-On Mfg. Co.

Cement (Refractory)
* Babcock & Wilcox Co.
* Botfield Refractories Co.
* Lavino, E. J., & Co.
* McLeod & Henry Co.

Cement (Water Resistant)
Smooth-On Mfg. Co.

Centrifugals (Chemical, Sugar)
* Worthington Pump & Mach'ry Corp'n

Chain Belts and Links
* Boston Gear Works Sales Co.
* Diamond Chain & Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Morse Chain Co.
* Whitney Mfg. Co.

Chains (Block)
* Boston Gear Works Sales Co.

Chains and Sprockets (Power Transmission)
* Boston Gear Works Sales Co.
* Diamond Chain & Mfg. Co.
* Link-Belt Co.
* Morse Chain Co.
* Philadelphia Gear Works
* Whitney Mfg. Co.

Charging Machines (Furnace)
* Shepard Niles Crane & Hoist Corp'n

Chucking Machines
* Jones & Lamson Machine Co.

Chucks (Magnetic)
* General Electric Co.

Chutes
* Breese Bros. Co.
* Link-Belt Co.

Circuit Breakers
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Clamps (Pipe and Pipe-Joint)
* Grinnell Co.
Walworth Co.
* Yarnall-Waring Co.

Clocks (Engine Room)
* Bristol Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Cloth (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Cloth (Tracing)
Weber, F., Co. (Inc.)

Clutches (Friction)
* Farrel-Birmingham Co. (Inc.)
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Philadelphia Gear Works
* Reeves Pulley Co.
Wood's, T. B., Sons Co.

Clutches (Reverse)
Johnson, Carlyle, Machine Co.

Coal and Ash Handling Machinery
* Combustion Engrg. Corp'n
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Coal Bins
* Erie City Iron Works
* Link-Belt Co.

Coal Breakers and Cleaners
* Pennsylvania Crusher Co.

Coal Mining Machinery
* General Electric Co.
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.

Coaling Stations (Locomotive)
* Link-Belt Co.

Cocks (Air and Gage)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fairbanks Co.
* Jenkins Bros.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
* Nicholson, W. H., & Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Cocks (Blow-Off)
* Crane Co.
* Fairbanks Co.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Coils (Pipe)
* Aluminum Co. of America
* Badger, E. B., & Sons Co.
* Grinnell Co.
Heat Transfer Products (Inc.)
* Midwest Piping & Supply Co.
* Superheater Co.
* Vogt, Henry, Machine Co.

Collars (Shaft)
* Link-Belt Co.
Wood's, T. B., Sons Co.

Coloring (Metal)
* American Metal Treatment Co.

Combustion (CO_2) Recorders
* Brown Instrument Co.
* Permutit Co.
* Republic Flow Meters Co.

Compressors (Air)
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Sullivan Machinery Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Compressors (Ammonia)
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Vogt, Henry, Machine Co.
* Worthington Pump & Mach'ry Corp'n

Compressors (Gas)
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Condensers (Ammonia)
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Vogt, Henry, Machine Co.

Condensers (Barometric)
* Buffalo Steam Pump Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Kellogg, M. W., Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Condensers (Jet)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Condensers (Surface)
* Allis-Chalmers Mfg. Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Conduit (Electrical)
* Aluminum Co. of America

Control Systems (Speed, Machinery)
* American Fluid Motors Co.
Oilgear Company

Controllers (Condensate)
* Bailey Meter Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Controllers (Damper)
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Controllers (Electric)
Allen-Bradley Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Controllers (Filter Rate)
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Controllers (Liquid Level)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Davis Regulator Co.
* Fisher Governor Co.
* General Electric Co.
* Simplex Valve & Meter Co.

Controllers (Valve, Electrically Operated)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.

Converters (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Conveying Machinery
* Combustion Engrg. Corp'n
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Conveying Systems (Pneumatic)
* Allen & Billmyre Co. (Inc.)
* Allington & Curtis Mfg. Co.
* Sturtevant, B. F., Co.

Conveying Systems (Pneumatic Powdered Coal)
* Fuller Lehigh Co.

Conveyors (Belt)
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.

Conveyors (Bucket, Pan or Apron)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.

Conveyors (Chain)
* Link-Belt Co.

Conveyors (Screw)
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.

Cooling Ponds (Spray)
* Badger, E. B., & Sons Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Cooling Towers
* Badger, E. B., & Sons Co.
Fluor Corporation (Ltd.)
* Foster Wheeler Corp'n
* Wheeler, C. H., Mfg. Co.

Copper (Drawn)
* Roebling's, John A., Sons Co.

Cork (Granulated and Corkboard)
* Armstrong Cork & Insulation Co.

Counters (Revolution)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Veeder-Root (Inc.)

Countershafts
* Builders Iron Foundry
Wood's, T. B., Sons Co.

Couplings (Compression)
* Nicholson, W. H., & Co.
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Couplings (Pipe)
* Crane Co.
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.
Walworth Co.

Couplings (Shaft)
* Allis-Chalmers Mfg. Co.
* Bartlett Hayward Co.
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Nicholson, W. H., & Co.
* Nordberg Mfg. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Smith & Serrell
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.
Wood's, T. B., Sons Co.

Couplings (Shaft, Cut-Off)
Johnson, Carlyle, Machine Co.

Couplings (Tubing)
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Couplings (Universal)
* Gears & Forgings (Inc.)
Wood's, T. B., Sons Co.

Coverings (Pipe and Tank)
* Armstrong Cork & Insulation Co.

Coverings (Steam Pipe)
* Armstrong Cork & Insulation Co.
Walworth Co.

Cranes (Electric Traveling)
* Armington Engineering Co.
* Shepard Niles Crane & Hoist Corp'n

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Cranes (Gantry)
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes (Hand Power)
* Armington Engineering Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes(Jib)
* Farrel-Birmingham Co. (Inc.)
* Shepard Niles Crane & Hoist Corp'n

Cranes (Transfer)
* Shepard Niles Crane & Hoist Corp'n

Crucibles (Graphite)
* Dixon, Joseph, Crucible Co.

Crushers (Clinker)
* Farrel-Birmingham Co. (Inc.)

Crushers (Coal)
* Erie City Iron Works
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
* Pennsylvania Crusher Co.
* Smidth, F. L., & Co.

Crushers (Gyratory)
* Kennedy-Van Saun Mfg. & Engrg. Corp'n

Crushers (Hammer)
* Pennsylvania Crusher Co.

Crushers (Jaw)
* Farrel-Birmingham Co. (Inc.)
* Kennedy-Van Saun Mfg. & Engrg. Corp'n

Crushers (Ore and Rock)
* Allis-Chalmers Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
* Nordberg Mfg. Co.
* Pennsylvania Crusher Co.

Crushers (Roll)
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
* Pennsylvania Crusher Co.

Crushing and Grinding Machinery
* Allis-Chalmers Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
* Pennsylvania Crusher Co.
* Smidth, F. L., & Co.
* Worthington Pump & Mach'ry Corp'n

Cups (Grease)
* Crane Co.
Gits Bros. Mfg. Co.
Lunkenheimer Co.
Walworth Co.

Cups (Oil)
* Consolidated Ashcroft Hancock Co. (Inc.)
Gits Bros. Mfg. Co.
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)
Walworth Co.

Cutters (Milling)
* Whitney Mfg. Co.

Cutters (Pipe)
Walworth Co.

Dehumidifying Apparatus
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
Heat Transfer Products (Inc.)
* Sturtevant, B. F., Co.

Desuperheaters
* Babcock & Wilcox Co.
* Superheater Co.

Die Heads (Thread Cutting, Self-opening)
* Jones & Lamson Machine Co.

Dies (Punching and Stamping)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Dies (Thread Cutting)
* Jones & Lamson Machine Co.
Walworth Co.

Digesters
* Erie City Iron Works
* Kellogg, M. W., Co.

Distilling Apparatus
* Vogt, Henry, Machine Co.

Doors (Steel, Fire)
* Lupton's, David, Sons Co.

Drafting Room Furniture
Weber, F., Co. (Inc.)

Drawing Instruments and Materials
Weber, F., Co. (Inc.)

Dredging Machinery
* Morris Machine Works

Dryers (Coal)
* Fuller Lehigh Co.
* Link-Belt Co.

Drying Apparatus
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
* Kellogg, M. W., Co.
* Link-Belt Co.
* Sturtevant, B. F., Co.

Dust Collecting Apparatus
* Allington & Curtis Mfg. Co.
* Allis-Chalmers Mfg. Co.
* Sturtevant, B. F., Co.

Dynamometers
* Consolidated Ashcroft Hancock Co. (Inc.)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.

Economizers, Fuel
* Babcock & Wilcox Co.
* Foster Wheeler Corp'n
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.

Economizers (Integral)
* Erie City Iron Works

Ejectors
* Consolidated Ashcroft Hancock Co. (Inc.)
* Schutte & Koerting Co.
* Wheeler, C. H., Mfg. Co.

Ejectors (Steam-Air)
* Worthington Pump & Mach'ry Corp'n

Electrodes (Arc Welding)
Quasi-Arc, Incorporated

Elevating and Conveying Machinery
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.

Elevators (Electric, Inclined, Portable, Telescopic)
Atlantic Elevator Co. (Inc.)
* Link-Belt Co.

Engine Guards
* Breese Bros. Co.

Engine Repairs
* Nordberg Mfg. Co.

Engine Stops
* Schutte & Koerting Co.

Engines (Gas)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Gasoline)
* Fairbanks, Morse & Co.
* Sturtevant, B. F., Co.

Engines (Hoisting)
* Fairbanks, Morse & Co.
* Morris Machine Works
* Nordberg Mfg. Co.

Engines (Marine, Oil)
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Marine, Steam)
* Nordberg Mfg. Co.

Engines (Oil)
* Bethlehem Steel Co.
* Fairbanks, Morse &
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Oil, Diesel)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Fairbanks, Morse & Co.
* Nordberg Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Steam, Corliss)
* Allis-Chalmers Mfg. Co.
Frick Co. (Inc.)
* Nordberg Mfg. Co.

Engines (Steam, Poppet Valve)
* Erie City Iron Works
* Nordberg Mfg. Co.

Engines (Steam, Throttling)
* Erie City Iron Works
* Troy Engine & Machine Co.

Engines (Steam, Una-Flow)
* Erie City Iron Works
Frick Co. (Inc.)
* Nordberg Mfg. Co.
* Troy Engine & Machine Co.

Evaporators
* Bartlett Hayward Co.
* Croll-Reynolds Engrg Co. (Inc.)
* Drying Systems (Inc.)
* Farrel-Birmingham Co.(Inc.)
* Foster Wheeler Corp'n
Heat Transfer Products (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.

Exhaust Heads
* Sturtevant, B. F., Co.
Walworth Co.

Exhaust Systems
* Allington & Curtis Mfg. Co.
* Sturtevant, B. F., Co.

Exhausters (Gas)
* Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Sturtevant, B. F., Co.

Extractors (Oil and Grease)
* Consolidated Ashcroft Hancock Co. (Inc.)

Fans (Exhaust)
* Allen & Billmyre Co. (Inc.)
* Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Feeders (Pulverized Fuel)
* Combustion Engrg. Corp'n
* Fuller Lehigh Co.
* Smidth, F. L., & Co.

Filters (Air)
Staynew Filter Corp'n

Filters (Air, Pipe Line)
Staynew Filter Corp'n

Filters (Oil)
Nugent, Wm. W., & Co. (Inc.)
* Permutit Co.

Filters (Water)
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Filtration Plants (Industrial)
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Fittings (Ammonia)
* Crane Co.
Frick Co. (Inc.)
Tube-Turns (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Brass)
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Fittings (Compression)
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)

Fittings (Corrosion Resisting)
Tube-Turns (Inc.)

Fittings (Flanged and Pipe)
* Barco Mfg. Co.
* Builders Iron Foundry
* Crane Co.
* Edward Valve & Mfg. Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Hydraulic)
* Crane Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Pipe-Brass, Bronze, Steel-Screwed and Flanged)
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Fittings for Pipe Welding
Tube-Turns (Inc.)

Fittings (Tank)
* Parker Appliance Co.

Fittings (Tube, Compression, Flared or Soldered)
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Flanges
* Crane Co.
* Edward Valve & Mfg. Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Taylor Forge & Pipe Works
* Vogt, Henry, Machine Co.
Walworth Co.

Flanges (Forged Steel)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
Edgewater Steel Co.
* Taylor Forge & Pipe Works
Walworth Co.

Flexible Shaft Outfits
Strand, N. A., & Co.

Floats (Copper)
* Nicholson, W. H., & Co.

Flood Lights (Acetylene)
* Oxweld Acetylene Co.

Floor Stands
* Chapman Valve Mfg. Co.
* Crane Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Wood's, T. B., Sons Co.

Flow Indicators
Nugent, Wm. W., & Co. (Inc.)

Flux (Welding)
* Oxweld Acetylene Co.

Fly Wheels
* Farrel-Birmingham Co. (Inc.)
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
Wood's, T. B., Sons Co.

Foil (Aluminum)
* Aluminum Co. of America

Forges
* Buffalo Forge Co.

Forgings (Aluminum)
* Aluminum Co. of America

Forgings (Iron and Steel)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Gears & Forgings (Inc.)
* Vogt, Henry, Machine Co.

Forgings (Monel Metal)
* International Nickel Co. (Inc.)

Forgings (Nickel)
* Gears & Forgings (Inc.)
* International Nickel Co. (Inc.)

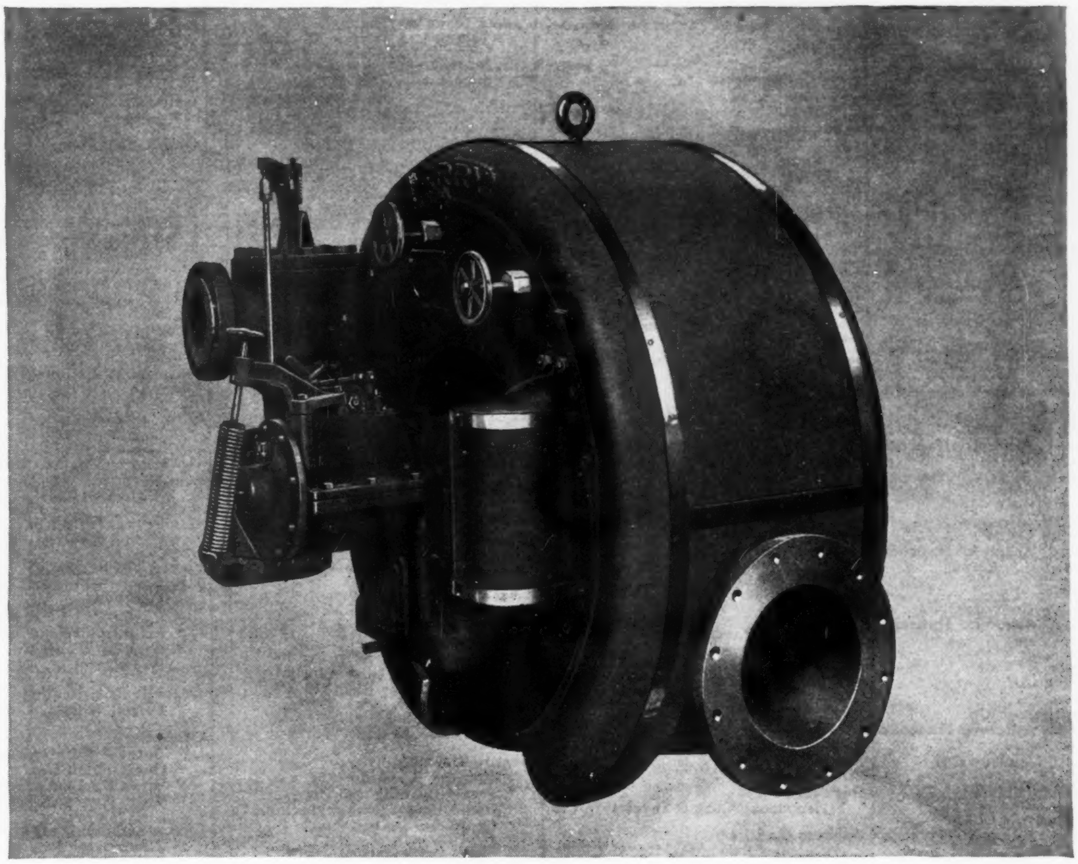
Foundations (Machinery, Cork)
* Armstrong Cork & Insulation Co.
Korfund Co. (Inc.)

Furnaces (Boiler)
* American Engineering Co.
* Babcock & Wilcox Co.
* Bernitz Furnace Appliance Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Riley Stoker Corp'n
* Taylor Forge & Pipe Works

Furnaces (Boiler, Smokeless)
* American Engineering Co.
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Riley Stoker Corp'n

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

TERRY



RELIABILITY FIRST!

Throughout the entire thirty-eight years that Terry Turbines have been on the market it has always been the Terry policy to build first of all for reliability.

That this policy has been appreciated is shown by the very extensive use of Terrys where only the most trustworthy apparatus is permissible: namely in the large central stations and on board vessels of the U. S. Navy.

75%, in fact, of the leading central station systems of the country employ Terry Turbines. Hundreds of Naval vessels depend on Terrys for driving the essential auxiliaries.

Engineering assistance on your turbine problems gladly furnished without obligation.

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1930-31 EDITION

The TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.
Steam Turbines - Gears - Shaft Couplings

T-1058

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Furnaces (Boiler, Water-Cooled)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Riley Stoker Corp'n

Furnaces (Industrial)
* Combustion Engrg. Corp'n
Detroit Electric Furnace Co.
* Erie City Iron Works
* Fuller Lehigh Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Furnaces (Powdered Coal)
* Combustion Engrg. Corp'n
* Erie City Iron works
* Fuller Lehigh Co.

Gage Boards
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gage Glasses
* Consolidated Ashcroft Hancock Co. (Inc.)
* Jenkins Bros.
Walworth Co.

Gage Testers
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Altitude)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Ammonia)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Vogt, Henry, Machine Co.

Gages (Differential Pressure)
* Bailey Meter Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.

Gages (Draft)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Peabody Engrg. Corp'n
* Republic Flow Meters Co.

Gages (Hydraulic)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Liquid Depth)
* Bailey Meter Co.
* Brown Instrument Co.

Gages (Liquid Level)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Gages (Loss of Head)
* Brown Instrument Co.
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Gages (Measuring, Surface, Depth, Dial, Etc.)
* Norma-Hoffmann Bearings Corp'n

Gages (Pressure)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Rate of Flow)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
Nugent, Wm. W., & Co. (Inc.)
* Simplex Valve & Meter Co.

Gages (Steam)
Nugent, Wm. W., & Co. (Inc.)

Gages (Vacuum)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Water)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
Nathan Mfg. Co.
Nugent, Wm. W., & Co. (Inc.)
Reading Steel Casting Co. (Inc.)
* Simplex Valve & Meter Co.
* Yarnall-Waring Co.

Gages (Water Level)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Lunkenheimer Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Gages (Water or Oil)
Nugent, Wm. W., & Co. (Inc.)

Gas (Acetylene)
* Prest-O-Lite Co.

Gas (Nitrogen)
* Linde Air Products Co.

Gas (Oxygen)
* Linde Air Products Co.

Gaskets
* Garlock Packing Co.
* Jenkins Bros.
Smooth-On Mfg. Co.
Walworth Co.

Gaskets (Copper-Cork)
* Armstrong Cork & Insulation Co.

Gaskets (Copper and Steel)
* Taylor Forge & Pipe Works

Gaskets (Cork)
* Armstrong Cork & Insulation Co.

Gaskets (Leather)
Chicago Rawhide Mfg. Co.

Gaskets (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Gates (Blast)
* Farrel-Birmingham Co. (Inc.)

Gates (Cut-Off)
* Link-Belt Co.

Gates (Sluice)
* Allen-Sherman-Hoff Co.
* Chapman Valve Mfg. Co.

Gear Blanks
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
Edgewater Steel Co.
* Farrel-Birmingham Co. (Inc.)
* Gears & Forgings (Inc.)

Gear Cutting Machines
* Gears & Forgings (Inc.)

Gears (Bevel)
Chicago Rawhide Mfg. Co.
* Gears & Forgings (Inc.)
* Hartford Special Machinery Co.
* Jones, W. A., Fdry. & Mach. Co.
Poole Engrg. & Machine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Bronze)
* Boston Gear Works Sales Co.
Chicago Rawhide Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.
Wood's, T. B., Sons Co.

Gears (Cast Iron)
Wood's, T. B., Sons Co.

Gears (Fibre)
* Boston Gear Works Sales Co.
Chicago Rawhide Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Friction Clutch)
Johnson, Carlyle, Machine Co.

Gears (Helical)
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Herringbone)
* Boston Gear Works Sales Co.
* Falk Corporation
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Machine Molded)
* Farrel-Birmingham Co. (Inc.)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
Poole Engrg. & Machine Co.

Gears (Phenalic Composition)
Chicago Rawhide Mfg. Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* James, D. O., Mfg. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Ratchet)
* Philadelphia Gear Works

Gears (Rawhide)
Chicago Rawhide Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Semi-Steel)
Wood's, T. B., Sons Co.

Gears (Speed Reduction)
* American Fluid Motors Co.
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Moore Steam Turbine Corp'n
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Shepard Niles Crane & Hoist Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Steel)
* Boston Gear Works Sales Co.
Chicago Rawhide Mfg. Co.
* Farrel-Birmingham Co., (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Worm)
Atlantic Elevator Co. (Inc.)
* Boston Gear Works Sales Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Hartford Special Machinery Co.
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Westinghouse Elect. & Mfg. Co.

Generating Sets
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Generator Cooling Systems
* Schutte & Koerting Co.

Generators (Acetylene)
* Oxweld Acetylene Co.

Generators (Electric)
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Lincoln Electric Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Generators (Gear)
* Farrel-Birmingham Co. (Inc.)

Governors (Air Compressor)
Walworth Co.

Governors (Engine, Oil)
* Nordberg Mfg. Co.

Governors (Engine, Steam)
* Nordberg Mfg. Co.
Walworth Co.

Governors (Oil Burner)
* Fisher Governor Co.

Governors (Pump)
* Bailey Meter Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Squires, C. E., Co.
Walworth Co.

Graphite (Lubricating, Flake)
* Dixon, Joseph, Crucible Co.

Grate Bars
* Botfield Refractories Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Vogt, Henry, Machine Co.

Grates (Dumping and Shaking)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Springfield Boiler Co.
* Vogt, Henry, Machine Co.

Greases
* Dixon, Joseph, Crucible Co.
Pure Oil Co.
Vacuum Oil Co.

Grinding Machines
Strand, N. A., & Co.

Grinding Machines (Floor)
* Builders Iron Foundry

Grinding Machines (Pneumatic, Portable)
* Ingersoll-Rand Co.

Gun Metal Finish
* American Metal Treatment Co.

Hammers (Drop)
* Farrel-Birmingham Co. (Inc.)

Hammers (Pneumatic)
* Farrel-Birmingham Co. (Inc.)
* Ingersoll-Rand Co.

Hangers (Pipe)
* Grinnell Co.

Hangers (Shaft)
* Jones, W. A., Fdry. & Mach. Co
* Link-Belt Co.
Wood's, T. B., Sons Co.

Hardening
* American Metal Treatment Co.

Haulers (Car)
* Link-Belt Co.

Headers (Welded)
* Grinnell Co.
* Kellogg, M. W., Co.
* Midwest Piping & Supply Co.
Walworth Co.

Heat Exchangers
* Babcock & Wilcox Co.
* Croll-Reynolds Engrg. Co. (Inc.)
* Foster Wheeler Corp'n
Heat Transfer Products (Inc.)
* Schutte & Koerting Co.
* Superheater Co.
* Wheeler, C. H., Mfg. Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Heat Treating
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Heaters (Oil)
* Coen Co. (Inc.)
* Foster Wheeler Corp'n
Heat Transfer Products (Inc.)
* Schutte & Koerting Co.

Heaters (Water Supply, Instantaneous)
* Consolidated Ashcroft Hancock Co. (Inc.)

Heaters and Purifiers (Feed Water)
* Combustion Engrg. Corp'n
* Croll-Reynolds Engrg Co. (Inc.)
* Erie City Iron Works
* Foster Wheeler Corp'n
Heat Transfer Products (Inc.)
* Schutte & Koerting Co.
* Wheeler, C. H., Mfg. Co.
* Wickes Boiler Co.
* Worthington Pump & Mach'ry Corp'n

Heating Devices (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Heating Specialties
* Fulton Sylphon Co.

Heating Systems
* Buffalo Forge Co.
* Drying Systems, Inc.)
* Grinnell Co.

Heating Systems (Unit)
* Buffalo Forge Co.
* Grinnell Co.
* Sturtevant, B. F., Co.

Heating Units (Hot Blast Heating Systems)
* Buffalo Forge Co.

Heating and Ventilating Apparatus
* Buffalo Forge Co.
* Sturtevant, B. F., Co.

Hoists (Air)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Sullivan Machinery Co.

Hoists (Electric)
* Allis-Chalmers Mfg. Co.
* American Engineering Co.
Atlantic Elevator Co. (Inc.)
* Fairbanks, Morse & Co.
* General Electric Co.
* Link-Belt Co.
* Nordberg Mfg. Co.
* Shepard Niles Crane & Hoist Corp'n

Hoists (Gate, Head, Tainter)
* Smith, S. Morgan, Co.

Hoists (Mine)
* Allis-Chalmers Mfg. Co.
* Nordberg Mfg. Co.

Hoists (Portable, Electric)
* Sullivan Machinery Co.

Hoists (Skip)
* Link-Belt Co.

Hoppers (Coal and Ash)
* Allen-Sherman-Hoff Co.
* Breese Bros. Co.
* Erie City Iron Works

Hose
* Fairbanks, Morse & Co.
Goodrich, B. F., Rubber Co.
* Ingersoll-Rand Co.

Humidifiers
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
Heat Transfer Products (Inc.)
* Sturtevant, B. F., Co.

Humidity Control
* Brown Instrument Co.
* Carrier Engineering Corp'n
* Sturtevant, B. F., Co.

Hydrants (Fire)
* Kennedy Valve Mfg. Co.
Reading Steel Casting Co. (Inc.)

Hydraulic Press Control Systems (Oil Pressure)
* American Fluid Motors Co.

Hydrokineters
* Schutte & Koerting Co.

Hygrometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Weber, F., Co. (Inc.)

Ice Making Machinery
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Vogt, Henry, Machine Co.

Idlers (Belt)
* Smidth, F. L., & Co.

Indicator Posts
* Crane Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Reading Steel Casting Co., (Inc.)
Walworth Co.

Indicator Reducing Motions
Nugent, Wm. W., & Co. (Inc.)

Indicators (CO, CO_2, SO_2)
* Brown Instrument Co.
* Permutit Co.

Indicators (Draft)
* Brown Instrument Co.
* Republic Flow Meters Co.

Indicators (Engine)
* Consolidated Ashcroft Hancock Co. (Inc.)

Indicators (Liquid Level)
* Bailey Meter Co.
* Brown Instrument Co.
* Fisher Governor Co.

Indicators (Sight Flow)
Nugent, Wm. W., & Co. (Inc.)

Indicators (Speed)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Veeder-Root (Inc.)

Indicators (Water Line)
* Bailey Meter Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Ingots (Aluminum)
* Aluminum Co. of America

Injectors
* Consolidated Ashcroft Hancock Co. (Inc.)
* Croll-Reynolds Engineering Co.
Nathan Mfg. Co.
* Schutte & Koerting Co.

Inspirators
* Consolidated Ashcroft Hancock Co. (Inc.)

Instruments (Electric Measuring)
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.
* Republic Flow Meters Co.
* Westinghouse Elect. & Mfg. Co.

Instruments (Hardness Measuring)
* Shore Instrument & Mfg. Co.

Instruments (Recording)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Consolidated Ashcroft Hancock Co. (Inc.)
* General Electric Co.
* Permutit Co.
* Republic Flow Meters Co.
* Westinghouse Elect. & Mfg. Co.
* Yarnall-Waring Co.

Instruments (Scientific)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Weber, F., Co. (Inc.)

Instruments (Surveying)
Weber, F., Co. (Inc.)

Insulating Materials (Electrical)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Insulating Materials (Heat and Cold)
* Armstrong Cork & Insulation Co.

Insulation (Boiler)
* Armstrong Cork & Insulation Co.

Insulation (Heat)
* Armstrong Cork & Insulation Co.

Insulation (Roof and Building)
* Armstrong Cork & Insulation Co.

Jigs and Fixtures
* Parker Appliance Co.

Joints (Expansion)
* Badger, E. B., & Sons Co.
* Barco Mfg. Co.
* Crane Co.
* Croll-Reynolds Engrg Co. (Inc.)
* Foster Wheeler Corp'n
* Grinnell Co.
Lunkenheimer Co.
* Parker Appliance Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.
* Yarnall-Waring Co.

Joints (Flanged Pipe)
* Barco Mfg. Co.
* Crane Co.
* Midwest Piping & Supply Co.
Walworth Co.

Joints (Flexible)
* Barco Mfg. Co.
Flexo Supply Co.

Joints (Swing and Swivel)
* Barco Mfg. Co.
Flexo Supply Co.
Lunkenheimer Co.
Walworth Co.

Joints (Universal)
* Boston Gear Works Sales Co.
* Gears & Forgings (Inc.)

Kettles (Copper)
* Breese Bros. Co.

Kettles (Steam Jacketed)
* Aluminum Co. of America
* Cole, R. D., Mfg. Co.
* Nordberg Mfg. Co.

Keys (Machine)
* Smith & Serrell
* Whitney Mfg. Co.

Lathes
* Jones & Lamson Machine Co.

Levers (Flexible, Wire)
* Gwilliam Co.

Linings (Clutch)
Chicago Rawhide Mfg. Co.

Linings (Furnace)
* Bernitz Furnace Appliance Co.
* Botfield Refractories Co.
* Lavino, E. J., & Co.
* McLeod & Henry Co.

Locomotives (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Locomotives (Oil Engine—Electric Driven)
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.

Locomotives (Storage Battery)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Louvres
* Breese Bros. Co.

Lubricants
* Dixon, Joseph, Crucible Co.
Pure Oil Co.
Vacuum Oil Co.

Lubricating Systems
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)

Lubricators
* Consolidated Ashcroft Hancock Co. (Inc.)
Gits Bros. Mfg. Co.
Lunkenheimer Co.
Nathan Mfg. Co.
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Machine Tool Feed Control Systems (Oil Pressure)
* American Fluid Motors Co.

Machine Work
* Builders Iron Foundry
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Hartford Special Machinery Co.
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.

Machinery Guards (Perforated Metal)
* Breese Bros. Co.

Manometers
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Mechanical Draft Apparatus
* Air Preheater Corp'n
* Buffalo Forge Co.
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.

Metal Treating
* American Metal Treatment Co.

Metals (Bearing)
* General Electric Co.

Metals (Extruded)
* Aluminum Co. of America

Metals (Welding)
Quasi-Arc Incorporated

Meters (Air and Gas)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.

Meters (Boiler Performance)
* Bailey Meter Co.
* Brown Instrument Co.
* Republic Flow Meters Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Meters (Coal)
* Bailey Meter Co.
* Republic Flow Meters Co.

Meters (Condensation)
* Bailey Meter Co.
* Simplex Valve & Meter Co.

Meters (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co

Meters (Feed Water)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Meters (Flow)
* Bailey Meter Co.
* Brown Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Yarnall-Waring Co.

Meters (Gasoline)
* Worthington Pump & Mach'ry Corp'n

Meters (Oil)
* Bailey Meter Co.
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n

Meters (Pitot Tube)
* Brown Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co

Meters (Steam)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.

Meters (V-Notch)
* Bailey Meter Co.
* Brown Instrument Co.
* Yarnall-Waring Co.

Meters (Venturi)
* Brown Instrument Co.
* Builders Iron Foundry
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

EASIER *and*

E-A-S-I-E-R!

THE photo below shows an off-set in a branch from main steam line, inserted to clear 12″ compressed-air line which has not yet been installed.

Notice two things: The compound turn *easily* fabricated from Tube-Turns, the stock fittings for pipe welding—

And the ease with which the insulation will be put around the smooth, even surfaces of the entire *welded* job!

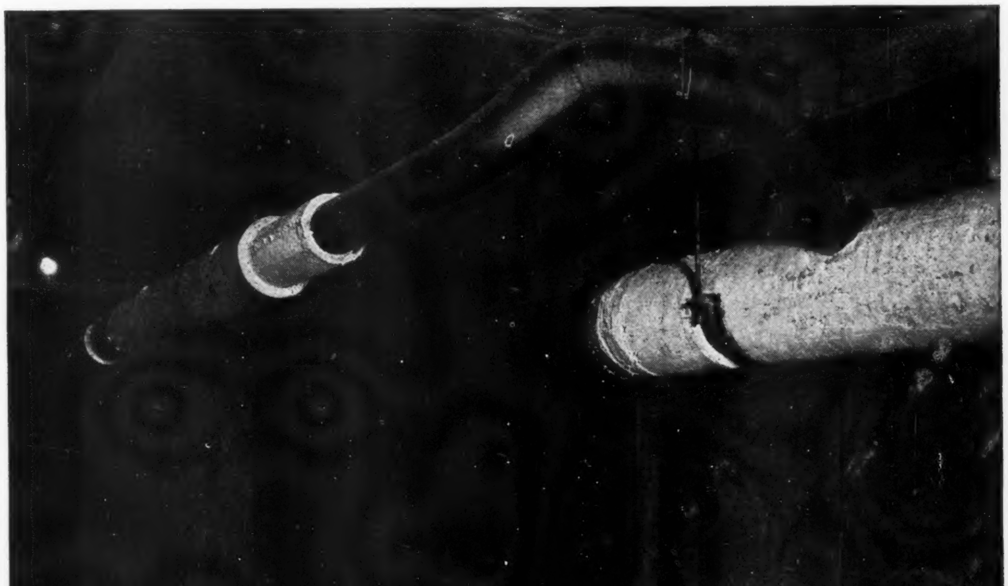
What TUBE-TURNS Are — and *DO*

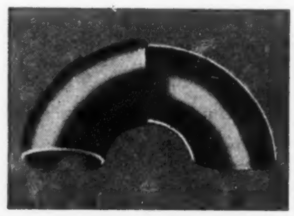
Tube-Turns are short-radius fittings for pipe welding, *forged* from seamless tubing. They are uniform in wall-thickness — no thinning of outside wall, no thickening or buckling of inside wall. They have a full, round cross-section — *less pressure drop.*

Tube-Turns speed the designing, estimating and installing of all piping. They are placed in the line with only *two* welds — each straight across the pipe. They are much stronger, much lighter, much easier to insulate. They eliminate maintenance and service calls for the contractor

— and can usually pay for themselves by savings in erection costs alone. Big claims, but easily proved — IF you say the word.

Address: TUBE-TURNS, *Incorporated,* 1303 South Shelby Street, Louisville, Ky.





TUBE-TURNS are made in 45°, 90° and 180° types, in 1″ through 18″ Standard I. P. S., and 1½″ through 12″ Extra-Heavy I. P. S. . . . Standard radius is 1½ times nominal pipe diameter. . . . *Stocked* by distributors in principal cities.

This scene is in the Chase Brass and Copper plant at Cleveland, Ohio. The Austin Co., *Engineers and Constructors;* The Smith & Oby Co., *Piping Contractors.* . . . Write today for a complete cost-analysis of one of the nation's most interesting jobs, in which welding *and Tube-Turns* were employed. Gladly sent you, without obligation, *on request!*

TUBE-TURNS

No Buckling of Inside Wall—No Thinning of Outside Wall

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Meters (Water)
* Bailey Meter Co.
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Mills (Ball)
* Allis-Chalmers Mfg. Co.
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Smidth, F. L., & Co.

Mills (Roll)
* Farrel-Birmingham Co. (Inc.)

Mills (Tube)
* Allis Chalmers Mfg. Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Smidth, F. L., & Co.

Mining Machinery
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Monel Metal
* International Nickel Co. (Inc.)

Motor-Generators
* Allis-Chalmers Mfg. Co.
* Century Electric Co.
* Fairbanks, Morse & Co.
* General Electric Co.
Roth Brothers & Co.
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Motors (Electric)
* Allis-Chalmers Mfg. Co.
* Century Electric Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Lincoln Electric Co.
Roth Brothers & Co.
* Shepard Niles Crane & Hoist Corp'n
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Nickel
* International Nickel Co. (Inc.)

Nozzles (Blast)
* Schutte & Koerting Co.

Nozzles (Boiler)
* Taylor Forge & Pipe Works

Nozzles (Sand and Air)
Lunkenheimer Co.

Nozzles (Spray)
* Badger, E. B., & Sons Co.
* Buffalo Forge Co.
* Grinnell Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Odometers
* Veeder-Root (Inc.)

Ohmeters
* General Electric Co.

Oil Burning Equipment
* Babcock & Wilcox Co.
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Peabody Engrg. Corp'n
* Schutte & Koerting Co.

Oil Cabinets
Nugent, Wm. W., & Co. (Inc.)

Oil Refinery Equipment
* Babcock & Wilcox Co.
* Bethlehem Steel Co.
* Foster Wheeler Corp'n
* Kellogg, M. W., Co.
* Vogt, Henry, Machine Co.
* Wheeler, C. H., Mfg. Co.

Oilers (Line Shaft from Floor)
Nugent, Wm. W., & Co. (Inc.)

Oilers (Multiple)
Nugent, Wm. W., & Co. (Inc.)

Oilers (Telescopic)
Nugent, Wm. W., & Co. (Inc.)

Oiling Devices
Gits Bros. Mfg. Co.
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)

Oiling Systems
Lunkenheimer Co.
Nugent, Wm. W., & Co. (Inc.)

Oils (Lubricating)
Dearborn Chemical Co.
Lindsay-McMillan Co.
Pure Oil Co.
Vacuum Oil Co.

Ore Handling Machinery
* Link-Belt Co.

Ovens (Conveyor)
* Drying Systems (Inc.)

Ovens (Core)
* Drying Systems (Inc.)

Ovens (Enameling, Japanning and Lacquering)
* Drying Systems (Inc.)
* Westinghouse Elect. & Mfg. Co.

Ovens (Japanning)
* Breese Bros. Co.
* Drying Systems (Inc)

Ovens (Sectional)
* Drying Systems (Inc.)

Oxy-Acetylene Supplies
* Linde Air Products Co.

Packing (Acid Resisting)
* Crane Packing Co.
* Garlock Packing Co.

Packing (Ammonia)
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Packing (Asbestos)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
Walworth Co.

Packing (Hydraulic)
Chicago Rawhide Mfg. Co.
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
Walworth Co.

Packing (Metallic)
* Crane Packing Co.
* Garlock Packing Co.
Walworth Co.

Packing (Metallic Condenser)
* Crane Packing Co.

Packing (Rod, Piston and Valve)
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.

Packing (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
Walworth Co.

Packing (Sheet)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
Walworth Co.

Paints (Aluminum)
* Aluminum Co. of America

Paints, Industrial (Casehardening)
* Shore Instrument & Mfg. Co.

Paints, Industrial (Concrete, Waterproofing)
Smooth-On Mfg. Co.

Paints, Industrial (Heat Resisting)
* Dixon, Joseph, Crucible Co.

Pans (Copper)
* Breese Bros. Co.

Pans (Machinery)
* Breese Bros. Co.

Paper (Drawing)
Weber, F., Co. (Inc.)

Paper (Sensitized)
Weber, F., Co. (Inc.)

Paraffin Wax Plant Equipment
* Bethlehem Steel Co.
* Kellogg, M. W., Co.
* Vogt, Henry, Machine Co.

Partitions (Steel)
* Lupton's, David, Sons Co.

Pawls
* Philadelphia Gear Works

Pencils (Drawing)
* Dixon, Joseph, Crucible Co.
Weber, F., Co. (Inc.)

Penstocks
* Kellogg, M. W., Co.
* Smith, S. Morgan, Co.
* Taylor Forge & Pipe Works

Pinions (Rolling Mill)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)

Pinions (Steel)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.

Pipe Bends
Heat Transfer Products (Inc.)

Pipe (Brass and Copper)
* Foster Wheeler Corp'n
Walworth Co.

Pipe (Cast Iron)
* Builders Iron Foundry
Walworth Co.

Pipe (Forge Welded)
* Taylor Forge & Pipe Works

Pipe (Riveted)
* Combustion Engrg. Corp'n
* Springfield Boiler Co.
* Taylor Forge & Pipe Works

Pipe (Spiral, Riveted)
* Taylor Forge & Pipe Works

Pipe (Steel)
* Bethlehem Steel Co.
* Crane Co.

Pipe (Welded)
* Crane Packing Co.
* Grinnell Co.
* Taylor Forge & Pipe Works
Walworth Co.

Pipe (Wrought Iron)
* Crane Co.
Walworth Co.

Pipe Bends
Frick Co. (Inc.)
* Grinnell Co.
Heat Transfer Products (Inc.)
* Midwest Piping & Supply Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Pipe Cutting and Threading Machines
* Crane Co.

Pipe Welding Fittings
Tube-Turns (Inc.)

Piping (Ammonia)
Frick Co. (Inc.)
* Grinnell Co

Piping (Power)
* Crane Co.
* Grinnell Co.
Heat Transfer Products (Inc.)
* Kellogg, M. W., Co.
* Midwest Piping & Supply Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Planimeters
* Bristol Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Weber, F., Co. (Inc.)

Plates (Cork, for Machinery Foundations)
Korfund Co. (Inc.)

Plugs (Fusible)
Walworth Co.

Polishing Machines
* Builders Iron Foundry

Powdered Fuel Equipment (for Boiler and Metallurgical Furnaces)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller Lehigh Co.
* Smidth, F. L., & Co.

Power Transmission Machinery
* Allis-Chalmers Mfg. Co.
* Diamond Chain & Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Morse Chain Co.
Poole Engrg. & Machine Co.
* Smidth, F. L., & Co.
* Smith, S. Morgan, Co.
* Westinghouse Elect. & Mfg. Co.
Wood's, T. B., Sons Co.

Preheaters (Air)
* Air Preheater Corp'n
* Babcock & Wilcox Co.
* Buffalo Forge Co.
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n
* Green Fuel Economizer Co.
* Ingersoll-Rand Co.

Presses (Baling)
* Farrel-Birmingham Co. (Inc.)

Presses (Broaching)
* Farrel-Birmingham Co. (Inc.)
Oilgear Company

Presses (Draw)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Extruding)
* Farrel-Birmingham Co. (Inc.)

Presses (Forming)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Hydraulic)
* Bethlehem Steel Co.
* Farrel-Birmingham Co. (Inc.)
Oilgear Company

Presses (Oily Waste and Rags)
Nugent, Wm. W., & Co. (Inc.)

Presses (Power)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Punching and Trimming)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Straightening)
* Farrel-Birmingham Co. (Inc.)
Oilgear Company

Presses (Toggle)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Wax)
* Vogt, Henry, Machine Co.

Producers (Gas)
* Bartlett Hayward Co.
* Westinghouse Elect. & Mfg. Co.

Pulleys
* Fairbanks, Morse & Co.
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Reeves Pulley Co.
Wood's, T. B., Sons Co.

Pulleys (Friction Clutch)
Johnson, Carlyle, Machine Co.

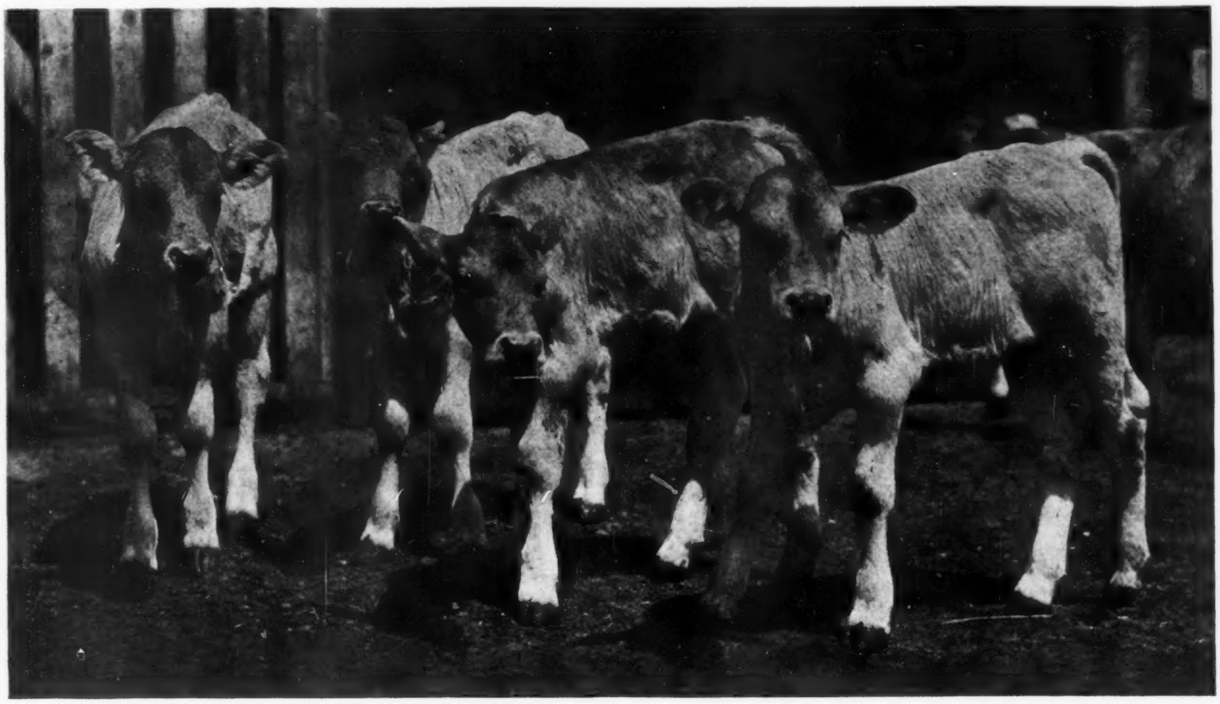
Pulleys (Magnetic)
* Reeves Pulley Co.

Pulverized Coal Burning Systems
* Bethlehem Steel Co.
* Coen Co. (Inc.)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Riley Stoker Corp'n
* Smidth, F. L., & Co.

Pulverized Fuel Unit Systems
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller Lehigh Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

PEDIGREE COUNTS IN OILS TOO



Pedigree Removes Guesswork

WITH pedigreed calves there is no doubt about the profits from investment in feed, to raise them to maturity. They inherit definite salable qualities which make them valuable. Buying pedigreed industrial oils removes the guesswork from the cost of maintenance of machinery. The superior lubricating qualities inherited and skillfully refined into Pure Oil's pedigreed oils, assures uninterrupted service, increased production and profits.

CABIN CREEK CRUDE

Ancestor to

PERFECT VALVE
Steam Cylinders

NULUBE TURBINE
Steam Turbines

SULTANA OILS
Air Compressors

SULTUR OILS
Diesel Engines

TIOLENE MOTOR OILS

THE PURE OIL COMPANY, U.S.A. PURE

For pedigreed oils to protect your machinery, 'phone, wire, or write nearest Pure Oil Co. office.

THE PURE OIL CO.

Producers, Refiners, Marketers of a complete line of petroleum products

+ REFINERIES: +

Marcus Hook, Pa. Heath, Ohio Muskogee, Okla. Ardmore, Okla.
Smith's Bluff, Texas Cabin Creek Jct., W. Va.

+ SALES OFFICES +

Chicago	Columbus	Minneapolis	New York
Bethlehem	Cincinnati	St. Paul	Newark, N. J.
Philadelphia	Dayton	Pittsburgh	Syracuse
Wilkes-Barre	Canton	Charleston	Troy
Akron	Indianapolis	Wheeling	Utica

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Pulverizers
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller Lehigh Co.
* Smidth, F. L., & Co.

Pulverizers (Cement Material)
* Bethlehem Steel Co.
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Pennsylvania Crusher Co.

Pulverizers (Coal)
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Pennsylvania Crusher Co.
* Riley Stoker Corp'n

Pulverizers (Limestone)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Fuller Lehigh Co.
* Pennsylvania Crusher Co.
* Riley Stoker Corp'n

Pulverizers (Refractory Material)
* Bethlehem Steel Co.
* Fuller Lehigh Co.

Pulverizers with Air Separators
* Bethlehem Steel Co.
* Erie City Iron Works
* Fuller Lehigh Co.
* Riley Stoker Corp'n

Pumping Outfits
* Pennsylvania Pump & Compressor Co.

Pumping Outfits (Fuel Oil)
* Coen Co. (Inc.)

Pumping Systems (Air Lift)
* Ingersoll-Rand Co.
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Acid)
* Buffalo Steam Pump Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
* Schutte & Koerting Co.
* Sullivan Machinery Co.
Taber Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Air)
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Sullivan Machinery Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Ammonia)
* Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Pennsylvania Pump & Compressor Co.
* Vogt, Henry, Machine Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Boiler Feed)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Pennsylvania Pump & Compressor Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Centrifugal)
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Foster Wheeler Corp'n
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Morris Machine Works
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
Taber Pump Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Condensation)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* Economy Pumping Mach'ry Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Quimby Pump Co. (Inc.)
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Deep Well)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Worthington Pump & Mach'ry Corp'n

Pumps (Dredging)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Worthington Pump & Mach'ry Corp'n

Pumps (Fire)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Fuel Oil Service)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Hand)
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
Taber Pump Co.

Pumps (Hydraulic)
* American Fluid Motors Co.
* Farrel-Birmingham Co. (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)

Pumps (Hydraulic Pressure)
* Buffalo Steam Pump Co.
* Farrel-Birmingham Co. (Inc.)
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
Oilgear Company
* Worthington Pump & Mach'ry Corp'n

Pumps (Mine)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Oil)
Nugent, Wm. W., & Co. (Inc.)
* Worthington Pump & Mach'ry Corp'n

Pumps (Oil, Pipe Line)
* Allis-Chalmers Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Oil, Variable Delivery)
Oilgear Company

Pumps (Rotary)
* Goulds Pumps (Inc.)
Oilgear Company
* Quimby Pump Co. (Inc.)
* Schutte & Koerting Co.
Taber Pump Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sewage)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Steam)
* Buffalo Steam Pump Co.
* Fairbanks, Morse & Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Nordberg Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sugar House)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sump)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
* Smidth, F. L., & Co.
Taber Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Turbine)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Morris Machine Works
* Pennsylvania Pump & Compressor Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Vacuum)
* Air Preheater Corp'n
* Buffalo Steam Pump Co.
* Croll-Reynolds Engrg Co. (Inc.)
* Economy Pumping Mach'ry Co.
* Foster Wheeler Corp'n
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Schutte & Koerting Co.
* Sullivan Machinery Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Vacuum, Steam Jet)
* Foster Wheeler Corp'n

Punches (Power)
* Buffalo Forge Co.
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Punching and Coping Machines
* Buffalo Forge Co.

Punching and Shearing Machnes
* Buffalo Forge Co.
* Farrel-Birmingham Co. (Inc.)

Purifiers (Ammonia)
Frick Co. (Inc.)

Purifiers (Feed Water, Boiler)
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Purifiers (Oil)
* De Laval Steam Turbine Co
Nugent, Wm. W., & Co. (Inc.)

Purifying and Softening Systems (Water)
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Pyrometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.
* Shore Instrument & Mfg. Co.
* Superheater Co.

Racks (Machine Cut)
* Boston Gear Works Sales Co
* Foote Bros. Gear & Machine Co
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Radiators (Steam and Water)
Smith, H. B., Co.
Walworth Co.

Rams (Hydraulic)
* Farrel-Birmingham Co. (Inc.)
* Goulds Pumps (Inc.)

Receivers (Air)
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Worthington Pump & Mach'ry Corp'n

Receivers (Ammonia)
Frick Co. (Inc.)

Refinery Equipment
* Bethlehem Steel Co.

Refractories
* Bernitz Furnace Appliance Co.
* Lavino, E. J., & Co.
* McLeod & Henry Co.

Refrigerating Machinery
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Vogt, Henry, Machine Co.

Regulators (Blower)
* Fisher Governor Co.

Regulators (Compressed Gas)
* Oxweld Acetylene Co.

Regulators (Damper)
* Brown Instrument Co.
* Fulton Sylphon Co.
Walworth Co.

Regulators (Electric)
Allen-Bradley Co.
* Brown Instrument Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Regulators (Fan Engine)
* Fisher Governor Co.
Walworth Co.

Regulators (Feed Water)
* Bailey Meter Co.
* Brown Instrument Co.
* Edward Valve & Mfg. Co.
* Squires, C. E., Co.

Regulators (Flow Steam)
* Brown Instrument Co.
* Schutte & Koerting Co.

Regulators (Humidity)
* Brown Instrument Co.
* Fulton Sylphon Co.

Regulators (Hydraulic Pressure)
* Bailey Meter Co.
* Farrel-Birmingham Co. (Inc.)
* Fisher Governor Co.

Regulators (Liquid Level)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.

Regulators (Pressure)
* Bailey Meter Co.
* Bristol Co.

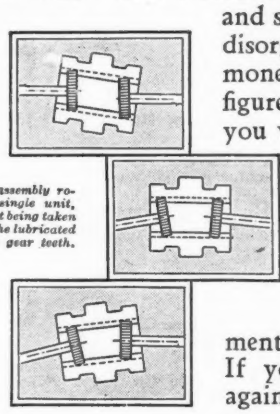
*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

FAST'S Self-Aligning COUPLING

"Here's the Answer to this Coupling Problem"

DO you have coupling break-downs resulting from the "fatigue" and failure of flexible members such as bushings, pins, springs, discs and grids?

By eliminating these flexible materials Fast furnished the answer to this baffling coupling problem. The simple mechanical principle has established a new and better coupling practice. Notice the diagrams at the right. Two spur gears are in complete and continuous mesh with the internal gears of a floating sleeve. The sleeve takes a neutral position, the error of misalignment being taken up between the lubricated faces of the gear teeth, and all necessity of flexible materials is eliminated.



The entire assembly rotates as a single unit, misalignment being taken up between the lubricated faces of the gear teeth.

Free From Shut-downs

Fast's Self-Aligning Couplings become part of the permanent transmission machinery of your plant. Give them the same care and they will last as long as the connected machines.

With Fast's Couplings your plant is free from production tie-ups formerly due to coupling break-downs. Check back over your records (or in your memory) and see how much delay, lost production and disorganized operation have cost you in both money and efficiency. Then compare this figure with the cost of installing Fast's and you will understand why they are economical.

Standardize on Fast's

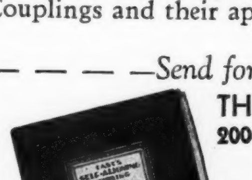
Thousands of plants throughout the country have standardized on Fast's Self-Aligning Couplings on all new equipment and for all replacements. Every installation requirement in your industry is met by Fast's design. If you specify Fast's you protect yourself against coupling break-downs. Any machinery or equipment builder will furnish them.

Mail the coupon to the Bartlett Hayward Company and receive a free copy of the new 10th Anniversary Catalog giving complete details of Fast's Self-Aligning Couplings and their application in your industry.

Cut-out type on 10,000 K. V. A. Frequency Changer, Appalachian Power Co., Switchback, W. Va.

—Send for NEW Catalog—

THE BARTLETT HAYWARD CO.
200 Scott Street - - Baltimore, Md.



Send me the free bound copy of the new Fast's 10th Anniversary Catalog showing varieties of designs and installations, containing valuable data on coupling installation.

NAME ____________________

FIRM NAME ____________________

ADDRESS ____________________

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
Walworth Co.

Regulators (Steam Flow)
* Bailey Meter Co.

Regulators (Temperature)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.

Regulators (Vacuum)
* Brown Instrument Co.
* Fisher Governor Co.
Walworth Co.

Regulators (Voltage, Automatic)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Regulators (Water Level)
* Bailey Meter Co.
* Davis Regulator Co.
* Fisher Governor Co.

Reheaters
* Babcock & Wilcox Co.
* Superheater Co.

Resuperheaters
* Babcock & Wilcox Co.
* Foster Wheeler Corp'n
* Superheater Co.

Rings (Weldless)
* Cann & Saul Steel Co.
Edgewater Steel Co.
* Gears & Forgings (Inc.)
* Taylor Forge & Pipe Works

Rivet Heaters (Electric)
* General Electric Co.

Riveters (Pneumatic)
* Ingersoll-Rand Co.

Rivets (Aluminum)
* Aluminum Co. of America

Rods (Aluminum)
* Aluminum Co. of America

Rods (Monel Metal)
* International Nickel Co. (Inc.)

Rods (Nickel)
* International Nickel Co. (Inc.)

Rods (Welding)
* Oxweld Acetylene Co.

Rolling Mill Machinery
* Farrel-Birmingham Co. (Inc.)

Rolls (Bending)
Niagara Machine & Tool Works

Rolls (Crushing)
* Allis-Chalmers Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Fuller Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.

Rolls (Forming, Sheet Metal)
Niagara Machine & Tool Works

Rope (Hoisting)
* Roebling's, John A., Sons Co.

Rope (Transmission)
* Link-Belt Co.
* Roebling's, John A., Sons Co.

Rope (Wire)
* Roebling's, John A., Sons Co.

Rope Drives
* Allis Chalmers Mfg. Co.
* Link-Belt Co.
Poole Engrg. & Machine Co.
Wood's, T. B., Sons Co.

Rubber Goods (Mechanical)
Goodrich, B. F., Rubber Co.
* Jenkins Bros.

Rust Proofing
Dearborn Chemical Co.

Sash (Steel)
* Lupton's, David, Sons Co.

Sash (Steel, Pivoted and Sliding)
* Lupton's, David, Sons Co.

Sash Operating Systems
* Lupton's, David, Sons Co.

Scales (Automatic, for all Purposes)
* Fairbanks Co.
* Fairbanks, Morse & Co.

Scales (Platform)
* Fairbanks Co.
* Fairbanks, Morse & Co.

Scleroscopes (Hardness Tester)
* Shore Instrument & Mfg. Co.

Screens (Revolving)
* Allis-Chalmers Mfg. Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Link-Belt Co.
* Smidth, F. L., & Co.

Screens (Shaking)
* Allis-Chalmers Mfg. Co.
* Link-Belt Co.

Screw Driving Machines
Strand, N. A., & Co.

Screw Machines (Hand)
* Jones & Lamson Mach. Co.

Screws (Drive, Hardened, for Metals)
* Parker-Kalon Corp'n

Screws (Safety Set)
Allen Mfg. Co.
* Bristol Co.

Screws (Self-Tapping, Hardened)
* Parker-Kalon Corp'n

Screws (Set)
Allen Mfg. Co.

Scrubbers (Air and Gas)
* Bartlett Hayward Co.

Separators (Ammonia)
Frick Co. (Inc.)
* Vogt, Henry, Machine Co.

Separators (Cinder)
Green Fuel Economizer Company

Separators (Oil)
* Crane Co.
Nugent, Wm. W., & Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Separators (Steam)
* Crane Co.
* Fisher Governor Co.
* Nicholson, W. H., & Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Shafting
Wood's, T. B., Sons Co.

Shafting (Cold Drawn)
* Bethlehem Steel Co.

Shafting (Flexible)
* Gwilliam Co.

Shears (Alligator)
* Farrel-Birmingham Co. (Inc.)

Shears (Rotary)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Shears (Squaring)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Sheaves (Rope)
* Jones, W. A., Fdry., & Mach. Co.
* Link-Belt Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
Wood's, T. B., Sons Co.

Sheet Metal Work
* Allington & Curtis Mfg. Co.
* Breese Bros. Co.

Sheet Metal Working Machinery
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Sheets (Aluminum)
* Aluminum Co. of America

Sheets (Monel Metal)
* International Nickel Co. (Inc.)

Sheets (Nickel)
* International Nickel Co. (Inc.)

Sheets (Rubber, Hard)
Goodrich, B. F., Rubber Co.

Sheets (Steel)
* Bethlehem Steel Co.

Shelving (Metal)
* Lupton's, David, Sons Co.

Siphons (Steam-Jet)
* Schutte & Koerting Co.

Slide Rules
Weber, F., Co. (Inc.)

Solder (Aluminum)
* Aluminum Co. of America

Soldering Irons (Acetylene)
* Prest-O-Lite Company

Sound Deadening Materials
Korfund Co. (Inc.)

Special Machinery
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Builders Iron Foundry
* Farrel-Birmingham Co. (Inc.)
* Gears & Forgings (Inc.)
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Smidth, F. L., & Co.

Speed Reducing Transmissions
* Allis-Chalmers Mfg. Co.
* American Fluid Motors Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Horsburgh & Scott Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Morse Chain Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Shepard Niles Crane & Hoist Corp'n
* Westinghouse Elect. & Mfg. Co.

Spray Cooling Systems
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Sprays (Water)
* Badger, E. B., & Sons Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Sprinkler Systems
* Grinnell Co.

Sprockets
* Boston Gear Works Sales Co.
* Diamond Chain & Mfg. Co.
* Foote Bros. Gear & Machine Co.
* Fuller Lehigh Co.
* Link-Belt Co.
* Morse Chain Co.
* Whitney Mfg. Co.

Sprockets (Friction Clutch)
Johnson, Carlyle, Machine Co.

Stacks (Steel)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Union Iron Works
* Vogt, Henry, Machine Co.

Stampings (Sheet Metal)
* Aluminum Co. of America
Stanley Elect. Tool Co.

Standpipes
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Fairbanks, Morse & Co.

Starters (Electric)
Allen-Bradley Co.
* Westinghouse Elect. & Mfg. Co.

Steam Specialties
* Crane Co.
* Fulton Sylphon Co.
Lunkenheimer Co.

Steel (Alloy)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
Stanley Elect. Tool Co.
* Timken Roller Bearing Co.

Steel (Bar)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Timken Roller Bearing Co.

Steel (Electric Furnace)
* Bethlehem Steel Co.
* Timken Roller Bearing Co.

Steel (Open-Hearth)
* Bethlehem Steel Co.
Stanley Elect. Tool Co.

* Falk Corporation
* Timken Roller Bearing Co.

Steel (Special Analysis)
* Timken Roller Bearing Co.

Steel (Stainless)
Stanley Elect. Tool Co.

Steel (Tool)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Timken Roller Bearing Co.

Steel Plate Construction
* Bethlehem Steel Co.
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Keeler, E., Co.
* Union Iron Works
* Vogt, Henry, Machine Co.

Stills
* Bethlehem Steel Co.
* Foster Wheeler Corp'n
* Kellogg, M. W., Co.
* Smith, A. O., Corp'n
* Vogt, Henry, Machine Co.

Stocks and Dies
Walworth Co.

Stokers (Chain Grate)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Westinghouse Elect. & Mfg. Co.

Stokers (Overfeed)
* Combustion Engrg. Corp'n
* Riley Stoker Corp'n
* Westinghouse Elect. & Mfg. Co.

Stokers (Side Feed)
* Riley Stoker Corp'n

Stokers (Traveling Grate)
* Riley Stoker Corp'n

Stokers (Underfeed)
* American Engrg. Co.
* Combustion Engrg. Corp'n
* Riley Stoker Corp'n
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Strainers (Oil)
* Coen Co. (Inc.)
* Davis Regulator Co.
* Fisher Governor Co.
Nugent, Wm. W., & Co. (Inc.)
* Schutte & Koerting Co.

Strainers (Steam)
* Davis Regulator Co.
* Fisher Governor Co.
* Schutte & Koerting Co.
Walworth Co.

Strainers (Water)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Davis Regulator Co.
* Fisher Governor Co.
* Schutte & Koerting Co.
Walworth Co.

Structural Steel Fabrication
* Bethlehem Steel Co.

Structural Steel Work
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works

Superheaters (Steam)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n
Heat Transfer Products (Inc.)
* Superheater Co.

Superheaters (Steam, Locomotive)
* Superheater Co.

Superheaters (Steam, Marine)
* Babcock & Wilcox Co.
* Foster Wheeler Corp'n
* Superheater Co.

Switchboards
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Switches (Electric)
Allen-Bradley Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Tables (Drawing)
Weber, F., Co. (Inc.)

Tachometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Veeder-Root (Inc.)

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

BEST BY TEST!

DELCO GREASE **"X" GREASE**

Delco

REG. U.S. PAT. OFF.

LEAD SOAP GREASE

LEAD-SOAP GREASE, when properly made, is the best heavy-duty gear lubricant known. However, through lack of careful selection of tested materials, or through careless compounding, it may defeat its own purpose.

One of its advantages is the small amount of colloidal lead which it deposits in the pores of gears or bearings—an invisible, friction-reducing protection . . . But if free litharge (lead oxide) is present, it destroys this prime advantage of lead-soap grease by offsetting its friction-defying properties with the abrasive effect of lead oxide.

The simple "free litharge" test above proves the freedom of Delco Lead-soap Grease from harmful fillers.

It's *all* lubricant. The kind that cuts overhead and increases machine efficiency.

All Delco Greases are built by Lindsay-McMillan Prescription Grease Service which specializes in fitting the proper lubricant to the tough job. Ask for our specifications for your lubricating problems.

25% solutions in chloroform were made of Delco No. 410 and another well-known lead-soap grease and centrifuged to compact the residue.

Delco shows an undeterminable amount of free litharge while the other has an amount equal to 2% by volume or 7% by weight. Which lubricant will serve your machinery best?

Delco REG. U.S. PAT. OFF.

INDUSTRIAL OIL-PRODUCTS

LINDSAY-McMILLAN CO. MFGRS.
MILWAUKEE · WISCONSIN
Plants: Savannah-Milwaukee

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

Tachoscopes
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Tank Work (Air, Gas, Oil and Water)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works

Tanks (Acid)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works

Tanks (Aluminum)
* Aluminum Co. of America

Tanks (Ash Storage, Cast Iron)
* Combustion Engrg. Corp'n

Tanks (Blow-Off)
* Erie City Iron Works

Tanks (Copper)
* Badger, E. B., & Sons Co.
* Breese Bros. Co.

Tanks (Elevated)
* Cole, R. D., Mfg. Co.

Tanks (Ice)
* Erie City Iron Works
Frick Co. (Inc.)

Tanks (Oil Storage)
Nugent, Wm. W., & Co. (Inc.)

Tanks (Pressure)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Ingersoll-Rand Co.
* Scaife, Wm. B., & Sons Co.
* Smith, A. O., Corp'n
* Vogt, Henry, Machine Co.

Tanks (Steel)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Union Iron Works
* Vogt, Henry, Machine Co.

Tanks (Storage)
* Allen-Sherman-Hoff Co.
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fairbanks, Morse & Co.
* Vogt, Henry, Machine Co.

Tanks (Tower)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n

Tanks (Welded)
* Aluminum Co. of America
* Cole, R. D., Mfg. Co.
* Kellogg, M. W., Co.
* Scaife, Wm. B., & Sons Co.

Tap Extensions
Allen Mfg. Co.

Taps and Dies
Walworth Co.

Thermometers
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Thermostats
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.
* General Electric Co.

Tile (Cork and Cork Composition)
* Armstrong Cork & Insulation Co.

Tires (Locomotive)
Edgewater Steel Co.

Tools (Pneumatic)
* Ingersoll-Rand Co.

Tools (Structural Workers)
Stanley Elect. Tool Co.

Tools (Thread Cutting)
* Crane Co.
* Jones & Lamson Machine Co.
Walworth Co.

Tools (Woodworkers Small)
Stanley Elect. Tool Co.

Torches (Brazing, Carbon Burning, Lead Burning, Etc.)
* Oxweld Acetylene Co.

Torches (Gas)
* Oxweld Acetylene Co.

Torches (Welding and Cutting)
* Prest-O-Lite Company

Trackwork (Industrial)
* Bethlehem Steel Co.

Tractors (Industrial, Gasoline)
* Allis-Chalmers Mfg. Co.

Tramrail Systems (Overhead)
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Tramways (Wire Rope)
* Roebling's, John A., Sons Co.

Transformers (Electric)
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Transmissions (Hydraulic)
Oilgear Company

Transmissions (Variable Speed)
* American Fluid Motors Co.
* Foote Bros. Gear & Machine Co.
Oilgear Company
* Reeves Pulley Co.

Traps (Oil)
* Fisher Governor Co.
* Nicholson, W. H., & Co.

Traps (Return)
* Crane Co.
* Fisher Governor Co.

Traps (Steam)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
* Jenkins Bros.
* Nicholson, W. H., & Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Squires, C. E., Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Traps (Vacuum)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Schutte & Koerting Co.

Trolleys
* Shepard Niles Crane & Hoist Corp'n
* Westinghouse Elect. & Mfg. Co.

Trolleys (Mine Railway including Pantagraphs)
* Westinghouse Elect. & Mfg. Co.

Trolleys (Monorail)
* Armington Engineering Co.

Trucks (Trailer)
* Fairbanks Co.

Tube Flaring Tools
* Parker Appliance Co.

Tube Cleaners (Boiler)
Walworth Co.

Tubes (Boiler, Charcoal Iron)
* Bethlehem Steel Co.

Tubes (Boiler, Seamless Steel)
* Babcock & Wilcox Co.
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n

Tubes (Condenser)
* Foster Wheeler Corp'n

Tubes (Pitot)
* Republic Flow Meters Co.

Tubing (Aluminum)
* Aluminum Co. of America
* Fulton Sylphon Co.
* Parker Appliance Co.

Tubing (Brass, Bronze and Copper, Seamless)
* Fulton Sylphon Co.
* Parker Appliance Co.

Tubing (Monel Metal)
* Fulton Sylphon Co.
* International Nickel Co. (Inc.)

Tubing (Nickel)
* Fulton Sylphon Co.
* International Nickel Co. (Inc.)

Tubing (Rubber)
Goodrich, B. F., Rubber Co.

Tumbling Barrels
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)

Turbines (Hydraulic)
* Allis-Chalmers Mfg. Co.
* Smith, S. Morgan, Co.

Turbines (Steam)
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Turbo-Blowers
* General Electric Co.
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.

Turbo-Compressors
* De Laval Steam Turbine Co.
* Ingersoll-Rand Co.
* Terry Steam Turbine Co.

Turbo-Generators
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Turbo-Pumps
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Terry Steam Turbine Co.

Turntables
* Link-Belt Co.

Unions
* Crane Co.
* Fairbanks Co.
Lunkenheimer Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Unloaders (Air Compressor)
* Ingersoll-Rand Co.
* Worthington Pump & Mach'ry Corp'n

Vaccum Breakers
* Schutte & Koerting Co.

Valve Discs
Chicago Rawhide Mfg. Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valve Operating Systems (Electric Remote Control)
* Bristol Co.
* Brown Instrument Co.

Valves (Air, Automatic)
* Bristol Co.
* Fisher Governor Co.

* Fulton Sylphon Co.
* Jenkins Bros.
* Simplex Valve & Meter Co.
Smith, H. B., Co.
Walworth Co.

Valves (Air, Operating)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fisher Governor Co.
* Homestead Valve Mfg. Co
* Merco Nordstrom Valve Co.

Valves (Air, Relief)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Edward Valve & Mfg. Co.
* Fulton Sylphon Co.
* Grinnell Co.

Lunkenheimer Co.
* Nordberg Mfg. Co.
Nugent, Wm. W., & Co. (Inc.
* Schutte & Koerting Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.

Valves (Altitude)
* Davis Regulator Co.
* Simplex Valve & Meter Co.

Valves (Ammonia)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Valves (Back Pressure)
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
* Jenkins Bros.
* Oxweld Acetylene Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Balanced)
* Bailey Meter Co.
* Brown Instrument Co.
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
Lunkenheimer Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves (Blow-off)
* Ashton Valve Co.
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Edward Valve & Mfg. Co.
* Fairbanks Co.
* Homestead Valve Mfg. Co.
* Jenkins Bros.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.
* Yarnall-Waring Co.

Valves (Butterfly)
* Chapman Valve Mfg. Co.
* Crane Co.
* Davis Regulator Co.
Lunkenheimer Co.
* Schutte & Koerting Co.
Walworth Co.

Valves (Check)
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Fairbanks Co.
* Fisher Governor Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Nathan Mfg. Co.
* Nordberg Mfg. Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Worthington Pump & Mach'ry Corp'n

Valves (Chronometer)
* Fisher Governor Co.
Walworth Co.

Valves (Combined Back Pressure and Relief)
* Fisher Governor Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

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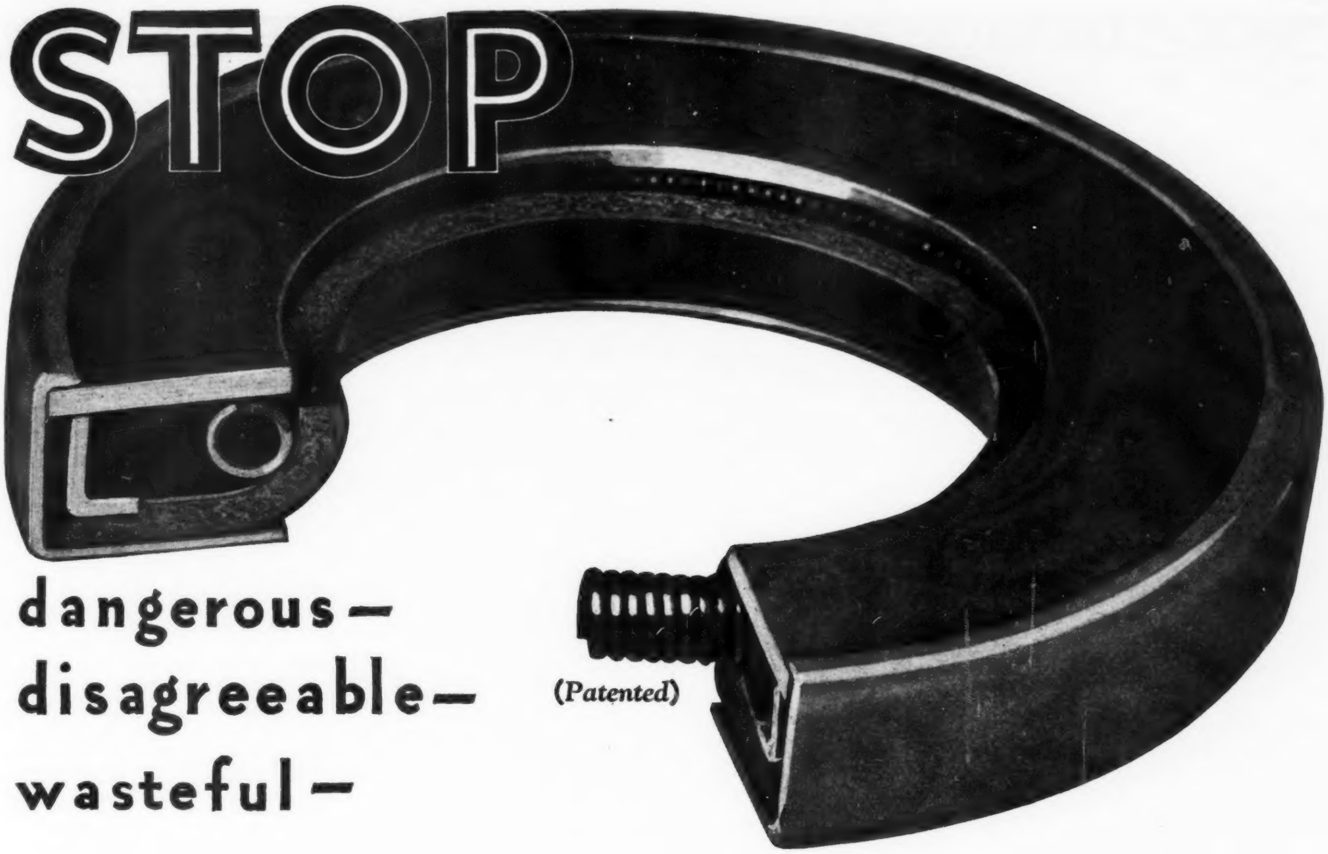

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disagreeable—
wasteful—

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Every lubricant seal application requires special consideration. Our engineers are thoroughly qualified to consider your problem and will welcome an opportunity to cooperate with you in arriving at its solution. Call in our counsel and profit by the experience of our experts. You incur no obligation.

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1305 ELSTON AVENUE, CHICAGO, ILL. BRANCHES: New York, Detroit, Cleveland, Philadelphia

THE PERFECT OIL RETAINER

IF MADE OF LEATHER FOR MECHANICAL PURPOSES, WE MAKE IT

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 172

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* Davis Regulator Co.
* Fisher Governor Co.

Valves (Diverting, Pulverized Fuel Pipe Line)
* Peabody Engrg. Co.

Valves (Electrically Operated)
* Bristol Co.
* Brown Instrument Co.
* Chapman Valve Mfg. Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.

Valves (Exhaust Relief)
* Crane Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Foster Wheeler Corp'n
* Jenkins Bros.
* Schutte & Koerting Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.

Valves (Float)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
* Schutte & Koerting Co.
* Simplex Valve & Meter Co.

Valves (Foot)
* Crane Co.
Walworth Co.
* Worthington Pump & Mach'ry Corp'n

Valves (Fuel Oil Shut-Off)
* Barco Mfg. Co.
* Brown Instrument Co.
* Schutte & Koerting Co.

Valves (Gate)
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fairbanks Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Globe, Angle and Cross)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Edward Valve & Mfg. Co.
* Fairbanks Co.
* Grinnell Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Nathan Mfg. Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Valves (Hose)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Crane Co.
* Fairbanks Co.
* Grinnell Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valves (Hydraulic)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Edward Valve & Mfg. Co.
* Fairbanks Co.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Yarnall-Waring Co.

Valves (Hydraulic Operating)
* Bailey Meter Co.
* Chapman Valve Mfg. Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Homestead Valve Mfg. Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Valves (Motor-Operated)
* Chapman Valve Mfg. Co.
* Edward Valve & Mfg. Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.

Valves (Needle)
Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Valves (Needle Point)
Nugent, Wm. W., & Co. (Inc.)

Valves (Non-Return)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Davis Regulator Co.
* Edward Valve & Mfg. Co.
* Jenkins Bros.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Plug)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fairbanks Co.
* Homestead Valve Mfg. Co.
* Merco Nordstrom Valve Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valves (Pop Safety)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Lunkenheimer Co.
Walworth Co.

Valves (Pump)
* Garlock Packing Co.
* Goulds Pumps (Inc.)
* Jenkins Bros.
* Nordberg Mfg. Co.

Valves (Radiator)
* Crane Co.
* Fairbanks Co.
* Fulton Sylphon Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valves (Radiator, Packless)
* Fulton Sylphon Co.

Valves (Reducing)
* Bailey Meter Co.
* Davis Regulator Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
* Oxweld Acetylene Co.
* Schutte & Koerting Co.
* Squires, C. E., Co.
Walworth Co.

Valves (Regulating)
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
Lunkenheimer Co.
* Simplex Valve & Meter Co.
Walworth Co.

Valves (Relief, Water)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Davis Regulator Co.
* Fisher Governor Co.
Lunkenheimer Co.
Walworth Co.

Valves (Safety)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Jenkins Bros.
Lunkenheimer Co.

Valves (Sight Feed)
Nugent, Wm. W., & Co. (Inc.)

Valves (Sight Flow)
Nugent, Wm. W., & Co. (Inc.)

Valves (Solenoid)
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.

Valves (Stop)
* Parker Appliance Co.

Valves (Superheated Steam, Steel)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Homestead Valve Mfg. Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
* Nordberg Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Yarnall-Waring Co.

Valves (Thermostatically Operated)
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.

Valves (Throttle)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Edward Valve & Mfg. Co.
* Fairbanks Co.
* Jenkins Bros.
Lunkenheimer Co.
* Nordberg Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Ventilating Systems
* Buffalo Forge Co.

Vibration Isolation Materials
Korfund Co. (Inc.)

Vises (Machine Tool)
* Hartford Special Machinery Co.

Voltmeters
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Washers (Leather)
Chicago Rawhide Mfg. Co.

Washers (Lock)
* Shakeproof Lock Washer Co.

Washers (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Washers (Thrust)
* Boston Gear Works Sales Co.

Water Columns
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Lunkenheimer Co.
Nathan Mfg. Co.
* Yarnall-Waring Co.

Water Purifying Plants
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Water Softeners
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Water Walls (Furnace)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller-Lehigh Co.
* Kennedy-Van Saun Mfg. & Engrg. Corp'n
* Springfield Boiler Co.
* Superheater Co.

Waterbacks (Furnace)
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n

Wattmeters
* Bristol Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Welding (Hammer Forge)
* Kellogg, M. W., Co.

Welding and Cutting Apparatus (Oxy-Acetylene)
* Linde Air Products Co.
* Oxweld Acetylene Company

Welding and Cutting Work
* Linde Air Products Co.

Welding Equipment (Electric)
* General Electric Co.
* Lincoln Electric Co.
Quasi-Arc Incorporated
* Westinghouse Elect. & Mfg. Co.

Welding Machines (Electric Arc Method)
Quasi-Arc Incorporated

Wheels (Steel Rolled)
Edgewater Steel Co.

Wheels (Trolley and Crane Track)
* Westinghouse Elect. & Mfg. Co.

Wheels (Truck, Factory)
* Fairbanks Co.

Whistles (Steam)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Lunkenheimer Co.
Nathan Mfg. Co.

Winches
* Ingersoll-Rand Co.
* Shepard Niles Crane & Hoist Corp'n

Windows (Steel, Industrial)
* Lupton's, David, Sons Co.

Wire (Aluminum)
* Aluminum Co. of America

Wire (Brass and Copper)
* Roebling's, John A., Sons Co.

Wire (Flat)
* Roebling's, John A., Sons Co.
Stanley Elect. Tool Co.

Wire (Iron and Steel)
* Bethlehem Steel Co.
* Roebling's, John A., Sons Co.

Wire (Welding)
* Aluminum Co. of America
* Lincoln Electric Co.
* Oxweld Acetylene Co.

Wire and Cables (Electrical)
* Aluminum Co. of America
* General Electric Co.
* Roebling's, John A., Sons Co.

Wire Mechanism (Bowden Wire)
* Gwilliam Co.

Wire Rope Fastenings
* Roebling's, John A., Sons Co.

Wire Rope Slings
* Roebling's, John A., Sons Co.

Wiring Devices
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Worm Gear Drives
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Foote Bros. Gear & Machine Co.
* James, D. O., Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.

Wrenches
* Roebling's, John A., Sons Co.
Walworth Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*

Cleaning the air reduces the wear

Pipe Line Filter

Pipe-line filtration is a definite and constant source of revenue. Compressed air drills, riveters, and other pneumatic tools wear longer and do better work. Sprayers deliver cleaner, purer paint with less danger of the fine spray nozzle becoming clogged by foreign matter. Anywhere that power lines from a central pressure tank are used, Protectomotor Filters in the pipe lines, as well as on the air intake of the compressor itself, will more than pay for themselves in the depreciation and grief they prevent.

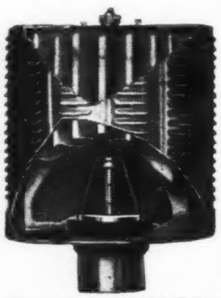
Removing water, oil, dirt, rust, scale and all other foreign substances from the air passing through the lines, they deliver air clean and dry.

PROTECTOMOTOR
REG. U.S. PAT. OFF.
99 9/10 Per Cent EFFICIENT
AIR FILTERS

consist of a felt filter element formed on a fine-wire screen shaped in fins, in an aluminum housing encased in a pressed steel shell with flanged joint made to withstand a working pressure of 125 lbs. Higher Pressure shells can also be supplied as special equipment.

Settlings of water, oil and sediment are withdrawn through a petcock, and by closing a valve to shut off air going into the filter housing, and opening the drain-cock, the air in the outlet pipes or hose blows back through the positive filter element removing all accumulations.

Write for booklet and information on our 30-day FREE TRIAL ORDER.



Protectomotor Air Filter
Eliminates 99-9/10% of dust and dirt from air delivered to machines. Reduces wear 75 to 85%. Cuts carbon deposits 60 to 70%. Saves oil. Muffles noise. Makes compressors, Diesel engines, etc. operate from 3 to 5 times longer before overhauling is necessary.

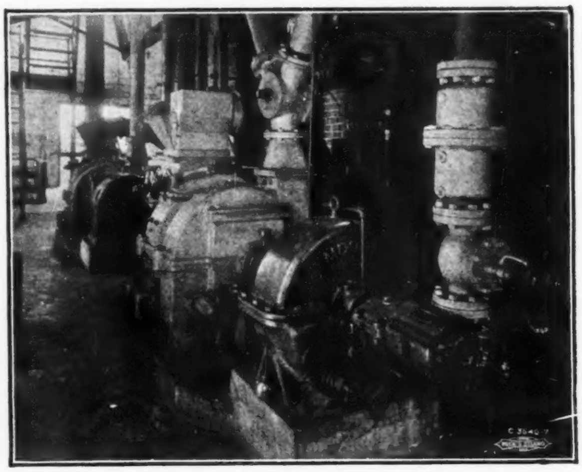
See Our Exhibit Booths 419-420 Power Show

Staynew Filter Corporation
19 Leighton Ave., Rochester, N. Y.

Staynew Filter Corp.,
19 Leighton Ave., Rochester, N. Y.
Please send a copy of your catalog on Protectomotor Air Filters for use on..............................
Name..............................
Address..............................
Town.................... State....................

MOORE

RELIABLE COAL PULVERIZER DRIVE



The rugged construction of Moore steam turbines makes them well suited for coal pulverizer drive.

Outstanding Features

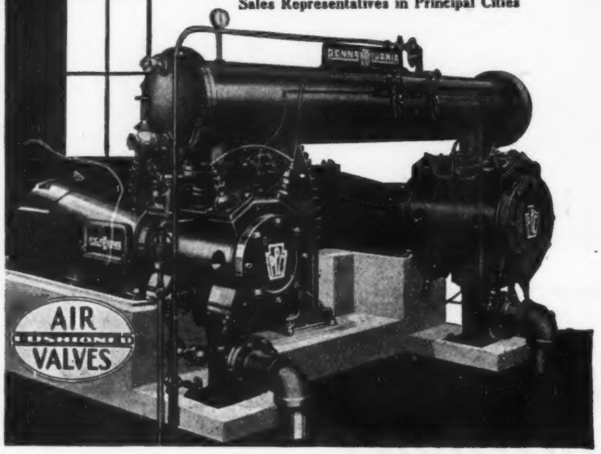
- Alloy steel shaft
- Large wheel clearances
- Heavy non-corrosive blading
- Rugged governor
- Dust proof bearing housings
- Heavy bronze bearings

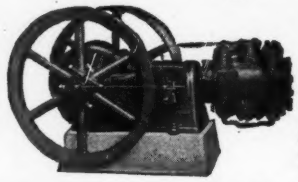
This construction assures continuous and reliable performance so essential for pulverizer drive.

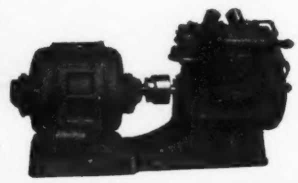
Steam Turbines Reduction Gears Centrifugal Pumps

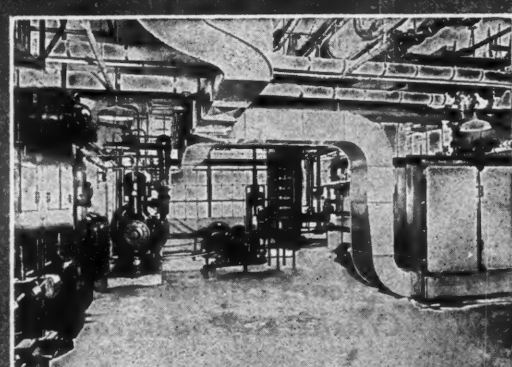
Offices in All Principal Cities

Moore Steam Turbine Corp.
Wellsville, N. Y.


AIR
VALVES







Test to Demonstrate the Effic

August 25, 1930

The purpose of this test was to critically examine the logic of the prevailing opinion that no tube holes should be placed in the welds of welded pressure vessels. The tests were witnessed by an accredited Navy Inspector.

Of course, the type of welds to be considered should first have demonstrated strength, ductility and impact values comparable with those of the plate before such a question as this needs to be raised.

In the test produced here, the plate material was made according to the same specifications as those governing the Super-heater Drums now under construction for the U. S. Navy. The specimens were made by the A. O. Smith Corporation for the U.S. Navy to show the effects of holes in and adjacent to the SMITH-Weld.

Material Specification

The specification for the steel calls for a minimum strength of 55,000 lbs. per square inch, a minimum yield point of one-half the ultimate strength and a minimum elongation of 30 per cent in 8 inches with the usual modifications for plate thickness.

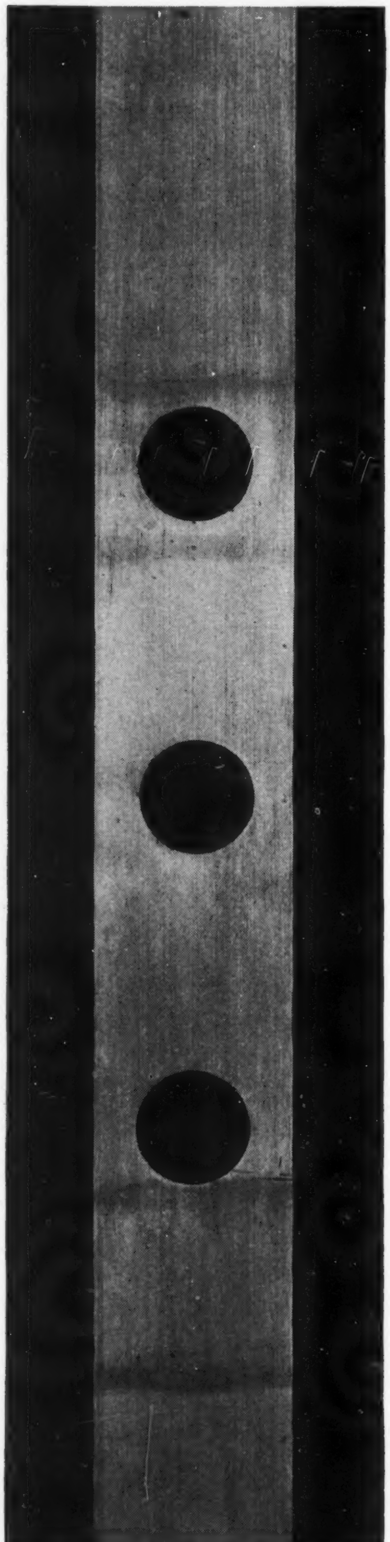


Figure 1

Test Set-up

The test specimen is shown in Figure 1. It consists of three pieces of plate $1\frac{1}{8}$ inches thick, which [illegible] welded together with the standard SMITH-Weld for the above class of steel.

The test specimen was designed so that one tube hole would be drilled in the center of one of the welds, the second tube hole adjacent to the other weld, and the third tube hole in the plate steel some distance from the welds.

The total width of the specimen is $2\frac{1}{4}$ inches, with tube holes $1\frac{1}{4}$ inches in diameter. The bead of the weld was entirely removed on both sides of the plate. The specimen was lightly etched to bring out the contour of the weld as shown in Figure 1.

Test Results

Figures 2 and 3, taken from opposite sides, show how the test specimen failed in the ligaments of the hole, which was drilled in the plate away from the welds.

The strength of the steel in the ligaments at failure was 63,300 lbs. per square inch.

A. O. SMITH

PRESSURE VESSEL DIVISION

iency of Tube Holes in Welds

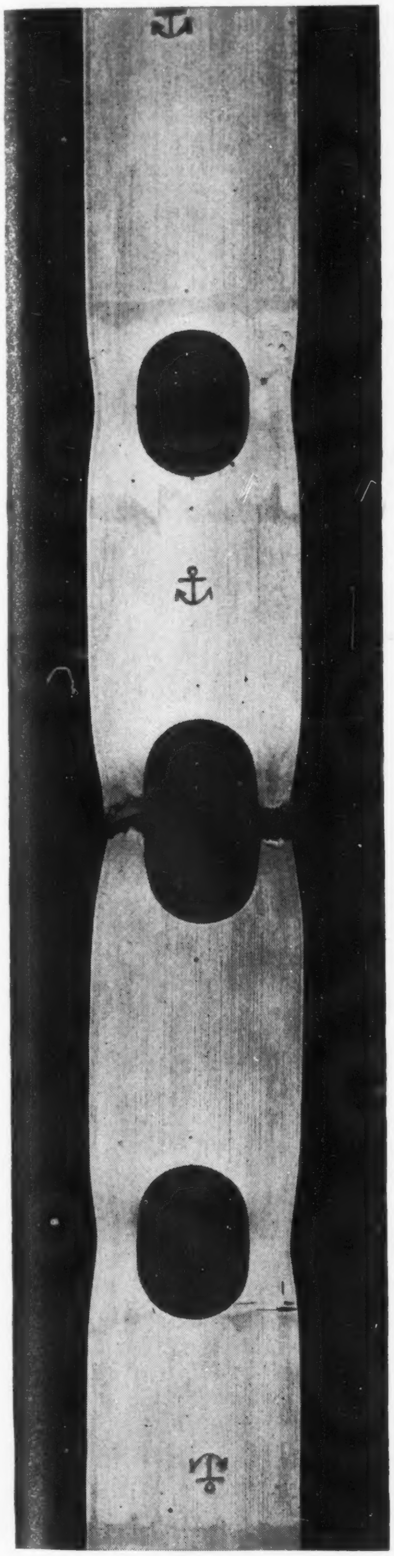


Figure 2

The yield point was 43,200 lbs. per square inch. The elongation was 25% in 2 inches and the reduction of area 48.8%. It is to be noted that elongation is not comparable with that resulting from pulling a uniform section of steel, because the two-inch gauge length was taken in line with the center of the holes and, naturally, part of the gauge length was in a much thicker section.

Conclusions

This test demonstrates that the ligaments of the tube hole in the weld are even stronger than the same size ligaments of plate material.

It will be noticed from Figures 2 and 3, that the weld ligament shows practically the same ductility as that of the plate.

It is therefore concluded that, if welds are comparable with the plate in strength, ductility and impact value, and if the welding does not impair the quality of the plate adjacent to the weld, then there is no reason to avoid placing tube holes in or near the weld.

T. McLEAN JASPER,
Director of Research
September 9, 1930
Milwaukee, Wisconsin

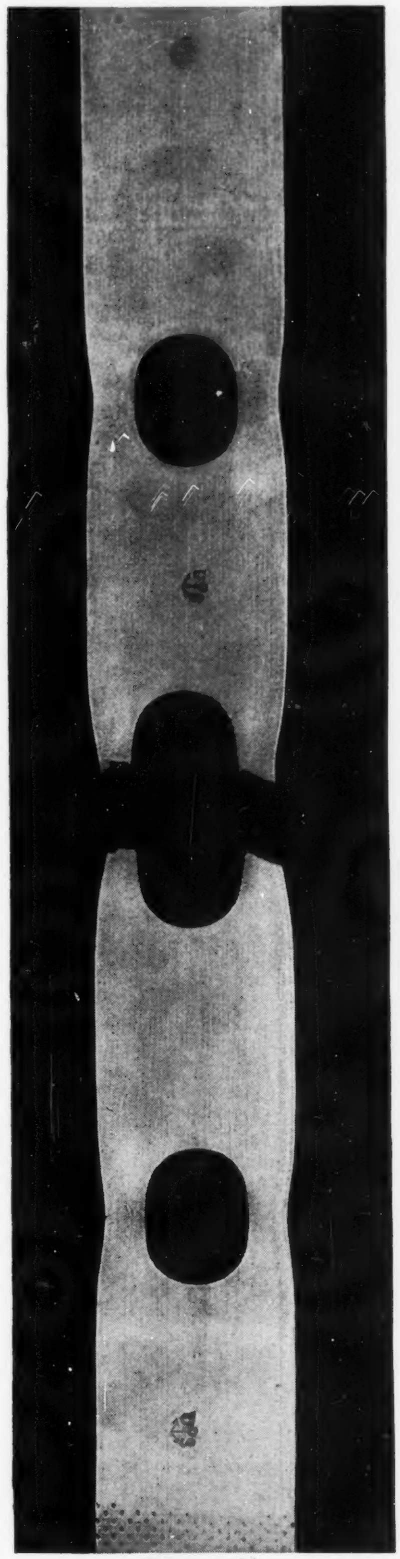


Figure 3

CORPORATION

General Offices: Milwaukee, Wisconsin


MECHANICAL
ENGINEERING
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Reaching
The Right Men
Economically
Since industry is depending so largely on the technical knowledge and engineering skill of mechanical engineers, it is entirely logical for industry to depend on the same knowledge and skill for the selection of apparatus and materials.
It is also logical for manufacturers to utilize the vehicle which is so definitely moving in the same direction in which mechanical engineers are moving, and covering the fields in which mechanical engineers are active.
MECHANICAL ENGINEERING is that vehicle. It is by and for mechanical engineers. Published monthly, it provides the dual advantage of effectiveness and economy.
Shall we send you complete information?
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS
29 West 39th Street, New York, N. Y.
Western Office: 205 Wacker Drive. Chicago, Ill.
A Journal for Engineers in All Industries

Will your speed reducers escape the Red Question Mark next year?

1930 has been a test-year for production costs.

With maintenance and operating figures carefully sifted . . . broken up into smaller lumps . . . cost items have been reviewed by super-critical eyes.

Red question marks have appeared more frequently on the cost sheets.

Exacting analysis has proved again that a single breakdown... men and machines standing idle for a few hours . . . production tie-ups . . . repairs quickly overbalance any saving in purchase price that can be made by specifying a less-than-first quality speed reduction unit.

More forcibly than ever, it has been demonstrated that the HIGHEST QUALITY SPEED REDUCER IS THE MOST ECONOMICAL.

Resolve now to "play safe" next year. Protect yourself by insisting on WORM GEAR speed reducers that will not fail when the sudden shocks and overloads come . . . speed reducers that require no attention outside of occasional oiling . . . speed reducers you can rely upon . . . "Clevelands".

CLEVELAND
WORM & GEAR COMPANY

3264 EAST 80TH STREET . . . CLEVELAND, OHIO

Cleveland Unit Type AT driving dryer. Ratio 8¾ : 1, . . . 5 h. p., 1200 r. p. m.

CLEVELAND WORM GEARING—THE ULTIMATE DRIVE

NO. 6 OF A SERIES—

THIS series of advertisements is designed to acquaint business men with Grinnell Company as it really is. Automatic Sprinkler protection is not the entire business of the Company. Its high reputation for many other industrial piping specialities and commodities has been built on super-standards of manufacture and on original conceptions which are well known to engineers and architects. Business men, too, need to know the real quality in these products.

The ORGANIZING HAND prepares for your NEEDS

Thermolier the copper unit heater. A better and cheaper means of heating many types of industrial and commercial buildings.

Grinnell Unit Coolers. A revolutionary improvement over pipe coils for room cooling and refrigeration.

Thermoflex Radiator Traps with the famous Hydron bellows, insuring perfect operation of your steam radiators.

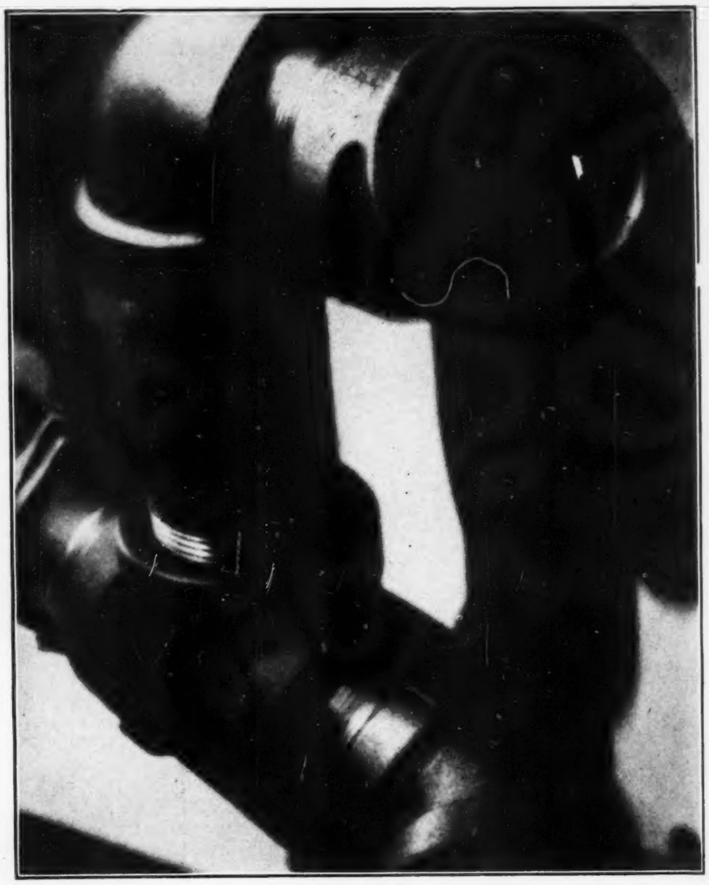
Pipe Fabrication. Pipe bends, welded headers and the Triple XXX line for super power work.

Pipe Fittings perfectly threaded, accurately machined and rigidly inspected.

Pipe Hangers featuring easy adjustability after the piping is up.

Humidification Equipment. Complete systems employing the unique automatic control, Amco.

Automatic Sprinkler Systems with the famous Quartz bulb head. The world's largest sprinkler manufacturer and contractor.



Pipe Fittings

for instance

EVEN a pipe fitting can be a fine masterpiece of casting threading and machining, or, it can be too crude to use in any high class piping system.

Leading engineers and contractors of America know why the Grinnell Company has never made *ordinary* fittings. Since super-quality fittings are needed for automatic sprinkler work that is the standard for all fittings made by Grinnell.

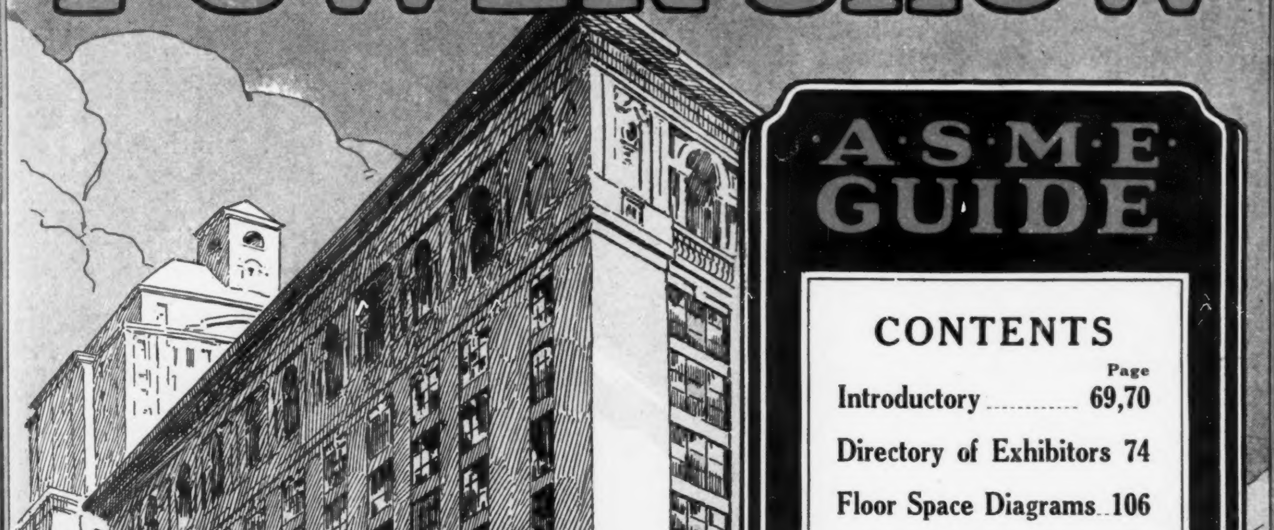
Contractors prefer Grinnell fittings because of ease and speed of construction. Building owners specify them because they want fine appearance and low maintenance. This applies equally to both the cast and malleable lines.

For the same two reasons, exactly, Grinnell adjustable pipe hangers win preference and are specified by architects, engineers and owners of buildings.

GRINNELL COMPANY

Branches in all Principal Cities Executive Offices: Providence, R. I

NATIONAL POWER SHOW



·A·S·M·E· GUIDE

CONTENTS

NINTH

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

At the ~ Grand Central Palace ~ New York, N.Y.

December 1st to 6th ,1930

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Ninth National Exposition of Power and Mechanical Engineering

THE "A.S.M.E. Guide" to the National Power Show although issued as an aid to A.S.M.E. members while attending the Show in person is also extremely valuable to those who are prevented by business or personal responsibilities from being in New York City during the week of the A.S.M.E. Annual Meeting and the Power Show.

Preliminary study of the "Guide" before visiting the Power Show helps a prospective visitor to select in advance those exhibits which seem most likely to be of definite value to him; and to give them first attention during his visit. In many instances also, the Guide will prove valuable after a visitor has left the Show as a means of checking up names, addresses, or details regarding the equipment examined.

MECHANICAL ENGINEERING presents again a complete "Directory of Exhibitors" giving a brief description of each exhibit so far as it has been possible to secure the information in advance of the Show. This data, which begins on page 74 and extends over alternate pages to page 92, has been compiled very carefully, and submitted to the Management of the Exposition for checking. We cannot guarantee its accuracy in de-

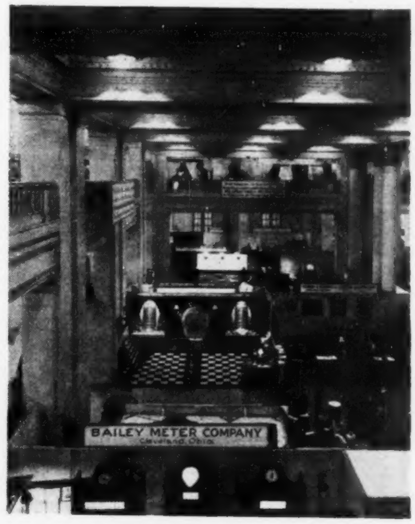
tail because of inevitable changes between the date of going to press and the opening of the Show. The names of concerns presenting advertisements in the "Guide" appear in color with a reference to the page or pages, upon which their advertisement appears.

In each write-up the number, or numbers, of the booths occupied are given, so that turning to the floor-space diagrams shown on pages 106, 108, and 110, a user of the Guide at the Show can readily locate any booth in which he is interested. A.S.M.E. members are especially invited to visit the A.S.M.E. Booth (No. 80) on the main floor near the front entrance, where members of the Staff will be in attendance throughout the Show, and full information regarding A.S.M.E. activities and publications will be available.

This year, more large working exhibits depicting power and mechanical engineering advancement will be presented than have ever been seen under one roof. Machinery and equipment in actual operation is what the engineer and his executives like to see, and there will be many new and spectacular treats in store for them. The Exposition is a great living catalog of engineering equipment, material and supplies typifying the progressive spirit of industry in this country. The problem of finding space to fit in new exhibitors this year has been a real one; and the Grand Central Palace will be crowded.

Conditions in general are such as to make a show at this time of more than usual value. A larger attendance than ever is expected because the average executive feels the need for keeping up to the minute in all methods of economy in these times and on the other hand business is not rushing at a pace to keep the important persons in the larger organizations too busy to attend.

Mechanical engineering development is advancing so fast in America that it is never possible to forecast the new devices that will appear within the span of a year. Many manufacturers have taken advantage of the lull of past months to develop new devices and improvements on old ones that will be shown for



the first time at the Power Show this year.

Indicative of the wide interest that is shown in this annual event, it is interesting to note that every state in the union was represented on the visitors list of those signing at the

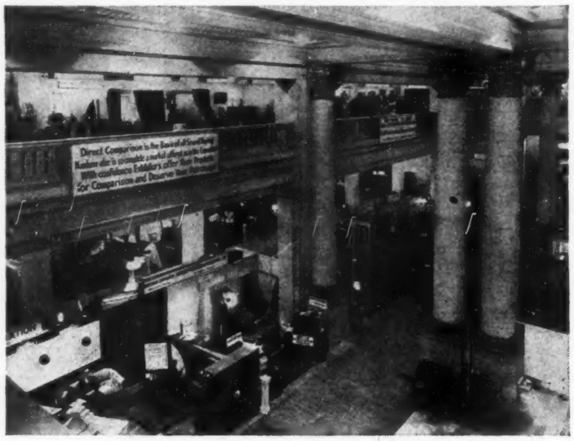
Continued on Page 70

Ninth National Exposition of Power and Mechanical Engineering

Continued from Page 69

door last year. The growth in interest in this field is indicated when we look back and see that there were only 105 exhibitors at the first show but more than four hundred have taken space to make this the best year that the National Power Show has had.

Boilers of the most modern type, of which in the past few years there has been a rapid development, will be visualized in unique ways by their manufacturers. Air preheating has become a standard practice in practically all plants of a certain type, and there will be several of these of different types to be seen. The various newer combinations of air preheater-water wall and boiler will be explained by their respective sponsors. The demands of the modern trend toward high pressures in boilers is reflected in the usually fine and diversified group of instrument makers who will show new devices.



A notable feature that has unquestionably taken form is the determination to show heavier and larger units, in many cases in actual operation. For instance, one nationally known manufacturer has arranged to show one of the largest units that go into the operation of a power plant insofar as fuel burning equipment is concerned, under practical operating conditions. Another interesting exhibit is that which relates to the stokers of various manufacturers, all of which are well represented. That air is an important factor in the production of power is emphasized by the exhibits of the fan makers who will, as seems to be the keynote of the show, exhibit larger and more complete units than heretofore, and even the air conditioning of the plant is receiving its share of attention with practical exhibits covering this point. There has always been an interest on the part of the coal companies and the fuel oil companies in the show. Their exhibits are among the most interesting.

Among the interesting electrical devices shown is a thermostatic device which operates on a variation of one-tenth of a degree. This thermo regulator will operate from the warmth of the hand and will be so arranged as to start a fan at the show. This may be applied to many industrial uses among which we might mention the explosive industry—safe-guarding against over-heating in the oil industry, where a uniform temperature is desired, and in fact in any industry where a close control of temperature is desirable. This is a new device.

With the demand for larger power plants a new demand for knowledge has come about. That is a knowledge of pipe and piping. Little was thought about it until it became an ever increasing factor in the design and construction as well as operation of the modern plant. To visualize this, one booth will show how piping and tubes are made. Along the same line is the exhibition of a special alloy steel that has heretofore not been shown at the power show, and indicates the refinements that are entering into the boiler room.

From valves to pumps, in both classes there is a wide range of material to be seen. A number of exhibits will relate to heating, ventilating or refrigeration, presenting the latest equipment among the standard, time-tried equipment in these fields.

More manufacturers of Power Transmission Equipment are exhibiting than ever before, showing many new devices, and modifications and improvements of old ones. Manufacturers of various types of Ball and Roller Bearings are presenting unique and instructive displays.

In material handling again will be found the influence of the larger higher duty plant reflected in the equipment to be shown. It is significant that more concerns in this line of business are exhibiting than any year heretofore.

Over fifty tool and machine tool manufacturers will exhibit. It is an apparent fact that the special tool and machine tool section of the Show, as is the case with all other sections, is paying more attention this year to complete working exhibits than ever before. The welding exhibits are of unusual interest.

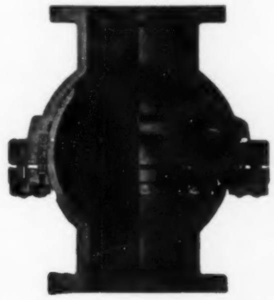
Of over 400 exhibitors who show their products, there is a surprising number of notations on the list "new exhibit not shown before."

As in previous years the National Power Show is being held during the same week as the A.S.M.E. Annual Meeting; and a special invitation is extended to all A.S.M.E. members to attend. Tickets of admission can be had without charge at Society Headquarters; and an A.S.M.E. emblem seldom fails to secure for its wearer even more than the usual degree of courteous attention accorded to visitors at booths. In many cases the managers of the booths are A.S.M.E. members themselves; and are glad accordingly, to welcome a visitor with whom they have a common interest.

BARCO FLEXIBLE JOINTS and SWIVEL JOINTS

Flexible Joints screw end
¼" to 6"

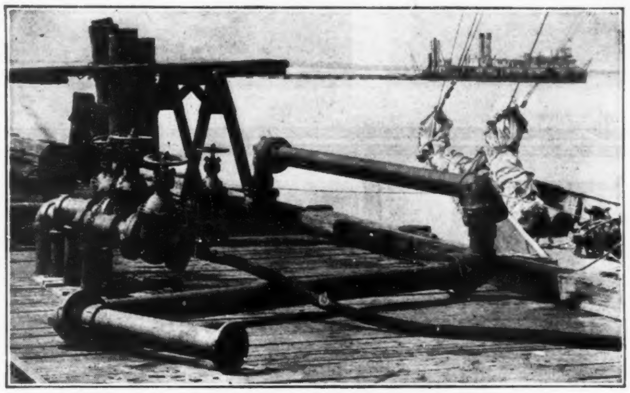
Swivel Joints screw end
½" to 1-¼".



Flexible Joints flange end
4" to 48"

Barco Joints are made in sizes from ¼" to 3" inclusive, of malleable iron; from ¼" to 2" inclusive of bronze; from 4" to 48" inclusive, of Semi-Steel.

Barco Standard Joints are suitable for 200 lb. steam pressure per sq. in., up to and including the 3" size whether made of bronze or malleable iron. The standard Semi-Steel joints 4", 5" and 6" are constructed for 125 lb. steam pressure.

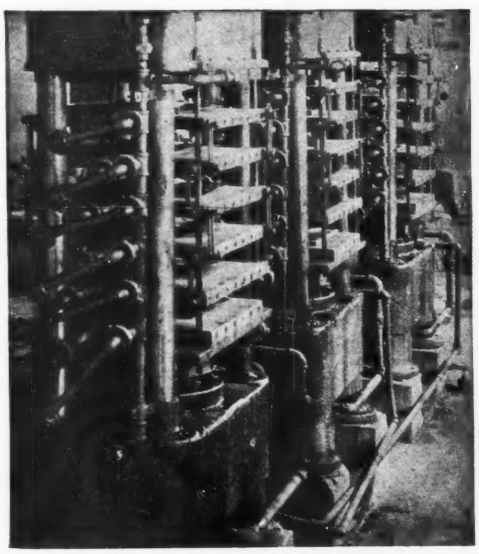


Barco Joints on oil loading and discharging docks

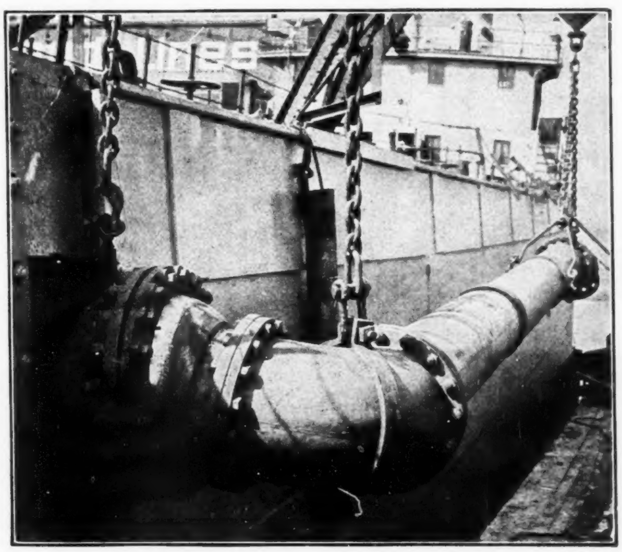
Barco Joints of all sizes can be made of special materials for special purpose such as to resist acids. They are also made extra heavy for high pressures.

The inside construction of all 4", 5" and 6" joints is like the screw end excepting but one gasket is used.

ASK FOR SPECIAL APPLICATION CATALOGS AND BLUE PRINTS



Barco Joints on platen press
Ask for Swivel Joint Catalog



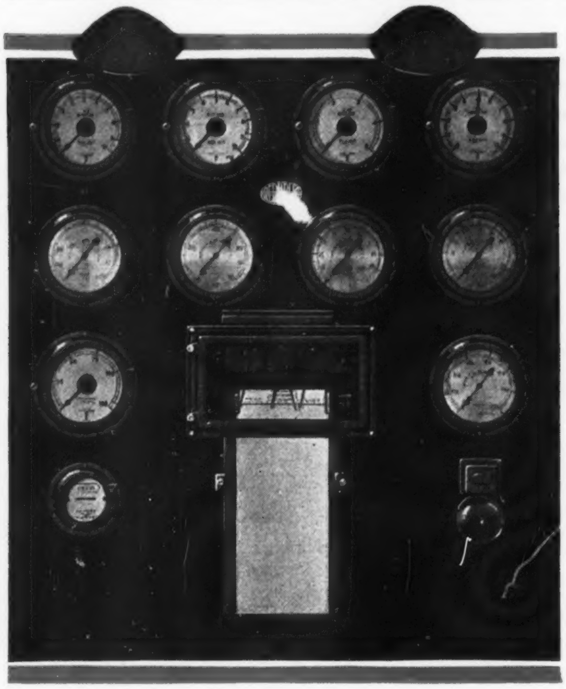
Barco Joints on suction dredges

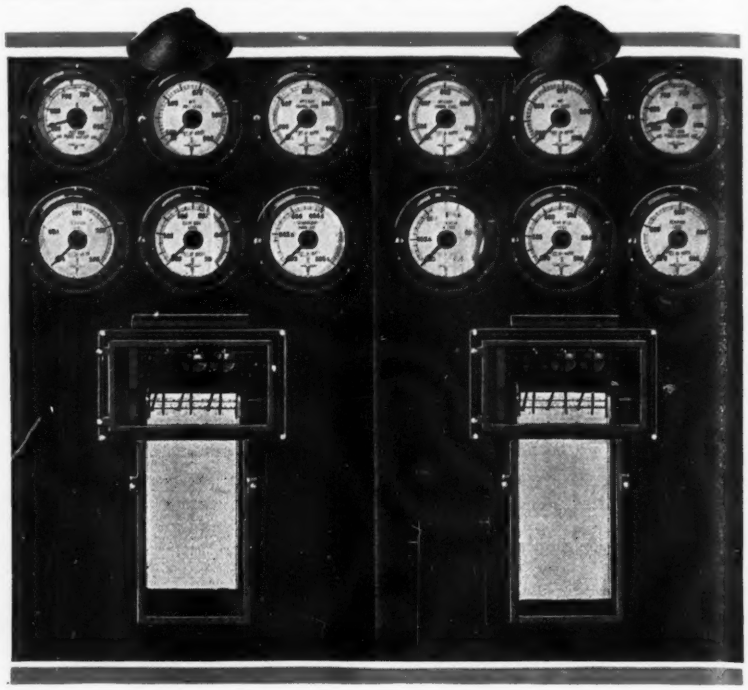
BARCO MANUFACTURING COMPANY

1801-1815 WINNEMAC AVENUE CHICAGO, ILL.

THE HOLDEN COMPANY, LIMITED—IN CANADA—MONTREAL-TORONTO-WINNIPEG-VANCOUVER

BOOTH 6—NATIONAL POWER SHOW

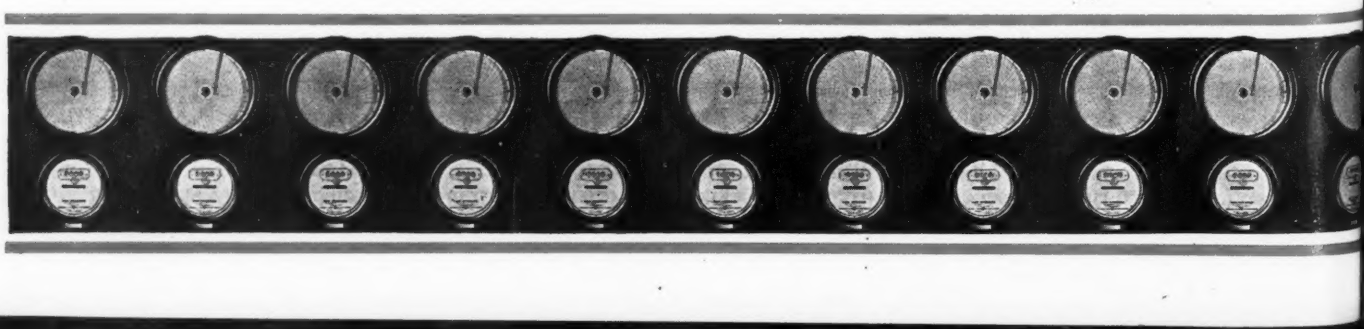


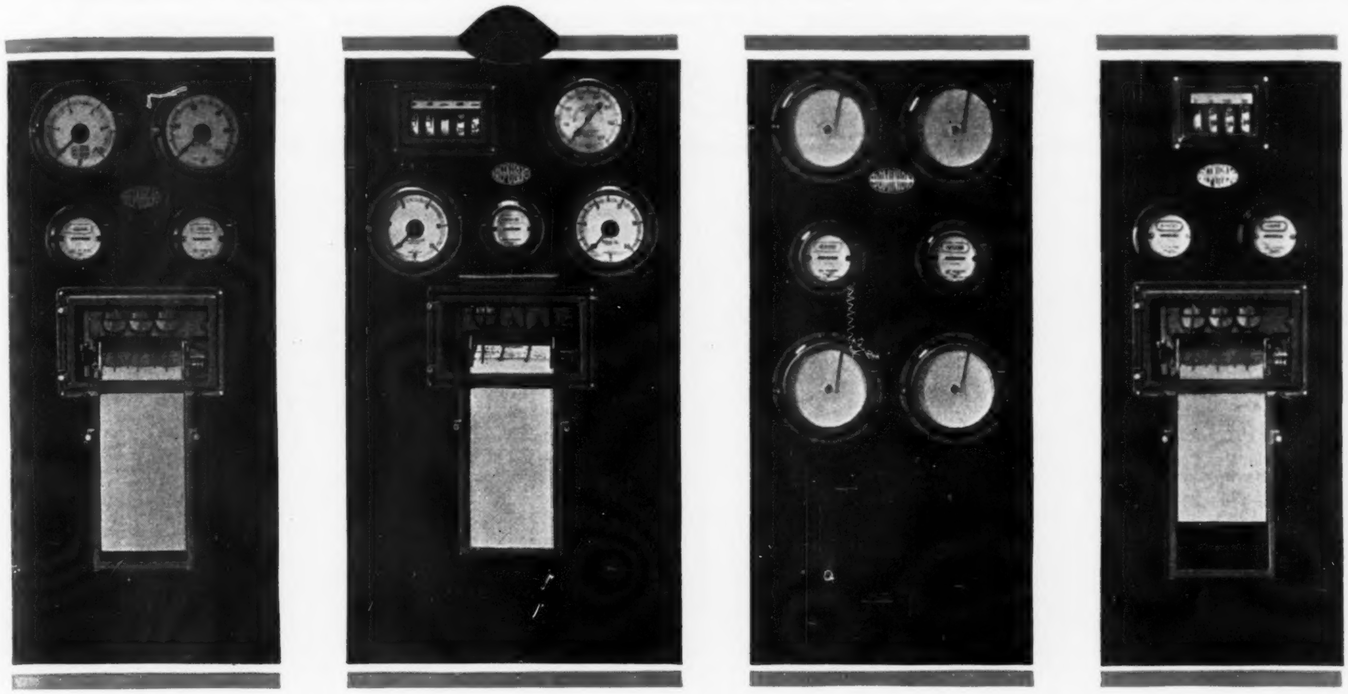


REPUBLIC

THE introduction of REPUBLIC electrically actuated meters made it possible to put the reading instruments just where they were most needed, irrespective of the distance from the measuring point . . . There also existed a real demand for a metering system which would produce co-ordinated records of related flows, pressures, vacuums, CO_2 percentage, etc., on a single chart and to show operating conditions at a glance . . . The new REPUBLIC master panels meet these requirements exactly. They produce these co-ordinated records on a 12″ wide continuous strip chart—electrically—at any location most convenient for the operator.

VISIT our Booth No. 6 at the New York Power Show and see these instruments in operation.





FLOW METERS

TURN THE WASTE OF TODAY INTO THE PROFITS OF TOMORROW

It is of great importance that you should realize there is nothing new or untried incorporated in REPUBLIC master panels . . . They are new in conception only; in the type and width of chart, and the arrangements of the recording movements . . . All the systems of measurement used are those which have been fitted in individual REPUBLIC instruments for many years past, and which have been proved to be thoroughly successful under working conditions similar to those in your plant.

Bulletin "Republic Economy in Industry" mailed upon request.

REPUBLIC FLOW METERS COMPANY
Executive Offices and Plant: 2232 Diversey Parkway, Chicago, Illinois
Branch Offices in 25 Principal Cities

REPUBLIC INSTRUMENTS

Ninth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 401 to 656—Third Floor—*Diagram on Page 110*

Corrected to November 18th **Booth**

Abrasive Machine Supply Company......520–521
Newark, N. J.
Representing: Black & Decker Company, and Van Dorn Electric Tool Company.

Advance Engineering Co................272–273
168 Washington St., New York, N. Y.
Representing: Armstrong Machine Works, Chicago-Wilcox Mfg. Company, A. W. Cash Company, Instant Water Heater Sales Division, and Smith-Monroe Company.

Aerofin Corp'n..........................14A
750 Frelinghuysen Ave., Newark, N. J.
Will display a complete line of Aerofin Heaters, covering Low Pressure, Universal and High Pressure Aerofin; also Booster Coils.

The Aerologist...........................607
121 North Clark Street, Chicago, Ill.

Alexander Bros. (Inc.)...............319–320
14 South St., Philadelphia, Pa.
......................See Adv. Page 94
The exhibit will feature Tentacular, a transmission belt, operating a generator drive on short centers with a pulley diameter ratio of 10:1. Tentacular being first of all the most efficient form of power transmission in the world, proper technical data and charts will be on display in order to verify the efficiency claims made for this belt drive.

Allan, A., & Sons..........................20
Harrison, N. J.
Showing the application of Allan Red Metal to pistons of Steam, Oil and Gas Engines, Air, Gas and Ammonia Compressors. Allan Metal bearing bushings cored and solid. Allan Metal Valve Discs.

Allegheny Steel Co........................600
Brackenridge, Pa.
Display will consist of a representative display of Allegheny alloys.

Allen & Billmyre Co., Inc..............213–214
480 Lexington Ave., New York, N. Y.
Exhibiting a complete line of TABCO Centrifugal Multi-Stage Blowers and Exhausters, Heavy Duty Portable and Industrial Vacuum Cleaners and also TABCO Stationary Vacuum Cleaners as applied to power plant work.

Allen-Bradley Co......................558–560
490 Clinton St., Milwaukee, Wis.
Will display representative items from their extensive line of Electrical Controlling Apparatus. New items to be featured include: Bulletin 830 Pressure Switch, Bulletin 840 Float Switch, and Bulletin 609 Hand Operated A. C. Starting Switch with Overload Breakers.

Allen Mfg. Co.......................Mezz. "A'
131 Sheldon St., Hartford, Conn.
Will exhibit a complete line of Allen products including Allen Hollow Set Screws, Allen Hollow Cap Screws, and Allen Hollow Pipe Plugs. The shoulder screw is a new development.

Allen-Sherman-Hoff Co..................62–63
233 S. 15th St., Philadelphia, Pa.
Will have a Hydroseal Ash Pump, A Hydrovactor, and a Wind Swept Valve on display. All three of these products will be cut away to clearly show the method of operation.

Allpax Co. (Inc.).........................640
Mamaroneck, N. Y.
Exhibiting Allpax, the packing that "packs all" in Coil Form and Loose Form.

Alsop Engineering Co..............210A, B, C
39 W. 60th St., New York, N. Y.
Manufacturers of Hy-Speed Portable Electric Mixers; Portable Electric Pumps; Vacuum Bottle Fillers; Electric Filter Tanks; Internal Pressure Filters; Gravity Asbestos Filters; Vacuum Laboratory Filters; Electric Vacuum Pumps; and Special machines. Also Blu-Glass Acid-Resisting Enameled Equipment and Glass Coated Tanks.

American Air Filter Co. (Inc.)..............3-M
Louisville, Kentucky
Features of the exhibit will include a new Airmat Window Ventilator and Air Cleaner, and Airmat Dust Arrester, and an Automatic Multi-Panel Air Filter.

American Arch Co. (Inc.)...................58
60 E. 42nd St., New York, N. Y.

American Blower Co...........314–315, 321–322
6000 Russell St., Detroit, Mich.
Exhibiting a No. 9 Sirocco Induced Draft Fan, Maximum Capacity 96,500 Cu. Ft. Per Minute, Static Pressure 8.6" Water Gauge, Brake H. P. 200, R.P.M. 695, Temperature of Gases 415° F.

Booth

American Brass Co..........................65
Waterbury, Conn.
Admiralty and Ambrac Condenser Tubes, Condenser Head Plates, Everdur Metal, Anaconda Welding Rods, Anaconda Brass Pipe, Copper Tubes for use with Compression Fittings, Extruded Shapes, Die-Pressed Parts, Rods, Bars, and Segments, and Anaconda Sheet Metal will be exhibited.

American Car & Foundry Co................201
30 Church St., New York, N. Y.
Showing the a.c.f. Three-Electrode Berwick Electric Rivet Heater and the a.c.f. Single Electrode Berwick Electric Metal (Forging) Heater.

American Engineering Co..................298
Cumberland & Aramingo Sts., Phila., Pa.
...................See Adv. Pages 114, 115
Will exhibit a modern Taylor Multiple Retort Underfeed Stoker which design has been in operation for a year or more. All of the latest improvements will be shown in connection with the stoker. By means of convenient stairways it will be possible for visitors to see every working part of the huge exhibit including the fin-type tuyeres, the rams, the drive, the individual pusher rod mechanisms, the ash pit, and the massive crusher rolls. With the exception of the crusher rolls the entire stoker will be in operation and controlled as though it were installed in a central station. Other products of the American Engineering Company will form a part of the exhibit. These highly successful stoker auxiliaries can be applied to all types of multiple retort stokers as well as to the Taylor, and to pulverized coal, oil or gas fired boilers. The Lo-Hed Hoist Division of the Company will feature a Lo-Hed plain trolley hoist in operation.

American Flexible Coupling Co..............93
Erie, Pa.
Will exhibit the "American" Flexible Coupling. The device consists of two halves between which is a floating member. Flexibility is accomplished by means of an engineering principle rather than through bending, flexing or stressing any parts.

American Gas Association (Inc.)..........7
Graybar Building, New York, N. Y.
......................See Adv. Page 107
Heating, cooling, and drying operations will demonstrate the versatility and adaptability of gas fuel at the exhibit that the American Gas Association is sponsoring. The following gas companies in the Metropolitan area are cooperating with the Association in arranging the exhibit: Consolidated Gas Company of New York, The Brooklyn Union Gas Company, the Brooklyn Borough Gas Company, and New York and Richmond Gas Company. Many of the latest types of gas appliances will be on display, most of them in actual operation. There will also be a large display of nationally-known products which have been processed by gas. Representatives of the Association and the cooperating gas companies will be in attendance at the booth at all times.

American Locomotive Co.......227–228, 338–339
30 Church St., New York, N. Y.
See Heat Transfer Products Co.

American Metal Hose Co..................206
Waterbury, Conn.
Will display a complete line of Flexible Metallic Hose and Tubing with suitable couplings and connections for them.

American Propeller Co....................429
220 Grindall St., Baltimore, Md.
Quietness and high efficiency main features of Paragon ventilating fans. Propeller core built like airplane propellers of selected birch laminations, then encased in heavy gauge Monel metal, resistant to acids, steam and heat. Exhaust, pressure, extension shaft fans, etc., shown.

American Pulley Co.......................437
4200 Wissahickon Ave., Philadelphia, Pa.
The products to be exhibited will include: Steel Split Pulleys, Pressed Steel Shaft Hangers, Pressed Steel Hand Trucks, Sprucolite Motor Pulleys, and V-belt Sheaves. Accessories and parts of the products will also be displayed.

American Radiator Co.....................544
40 W. 40th St., New York, N. Y.
There will be exhibited the complete line of Mercoid controlling devices for temperature, pressure, vacuum and mechanical operation, motor operated valves and Solenoid Valves.

Booth

Included in this exhibit will be a display of the new Arco Radiatherm, a control to maintain room temperature by individual control of each radiator.

American Society of Heating & Ventilating Engineers.............................242–243
51 Madison Ave., New York, N. Y.
Facilities will be provided for welcoming Society members and furnishing all information concerning Society activities.

American Society of Mechanical Engineers....80
29 West 39th St., New York, N. Y.
A.S.M.E. Headquarters at the Power Show. Information may be had about Annual Meeting and other A.S.M.E. activities. Publications of the Society will be on exhibition.

American Steam Automobile Co.............406
Newton, Mass.
Showing small steam boilers for high and low pressures, also burners and accessories. A new type of water-tube boiler, especially suitable to high pressures, will be exhibited, also complete steam generating outfits for special processes, motor boats, and automobiles.

American Water Softener Co...............604
Lehigh Ave. & 4th St., Philadelphia, Pa.
Exhibit will be divided into three parts as follows: (1) The Filter Exhibit. (2) The Chemical Treating Exhibit. (3) The Acid Pump Exhibit.

Ames Pump Co. (Inc.).................227–228
30 Church St., New York, N. Y.
Will exhibit Pumping Apparatus for use in connection with vacuum heating systems with particular reference to the vacuum pump with detailed parts shown in sections in order to describe and illustrate the unit.

Amthor Testing Instrument Co. (Inc.).......611
309 Johnson St., Brooklyn, N. Y.
Will exhibit a complete line of Tachometers, (portable and stationary, indicating and recording); Tachoscopes (portable and stationary) Speed Indicators; Pressure Gauge Testers; "U" Gauges; Tensile Strength Testers; Quadrant Scales for various materials; and various other testing equipment and instruments of precision.

Anaconda Copper Mining Co.................65
25 Broadway, New York, N. Y.
Admiralty and Ambrac Condenser Tubes, Condenser Head Plates, Everdur Metal, Anaconda Welding Rods, Anaconda Brass Pipe, Copper Tubes for use with Compression Fittings, Extruded Shapes, Die-Pressed Parts, Rods, Bars, and Segments, and Anaconda Sheet Metal will be exhibited.

Andale Company............................92
1600 Arch St., Philadelphia, Pa.
Exhibit will include a self-cleaning, continuous Rotrex Strainer, also Duplex and Simplex Strainers; an Oil Cooler and an Oil Heater.

Appleton Electric Co......................510
1739 Wellington Ave., Chicago, Ill.
Will exhibit Threaded and No-Thread Malleable Unilets, (Conduit Fittings); also Portable and Constant Duty Reelites (Automatic extension reel for conveying electric current to electrically operated portable machinery).

Armstrong Cork & Insulation Co........277–278
911 Concord St., Lancaster, Pa.
The background of their booth will be a decorative display showing a Spanish scene, the central feature of which will be a cut out cork tree. The entire exhibit will tie in with their current educational campaign designed to acquaint the public with the origin of cork, processes of manufacture, the unique properties of this material, and its many industrial uses.

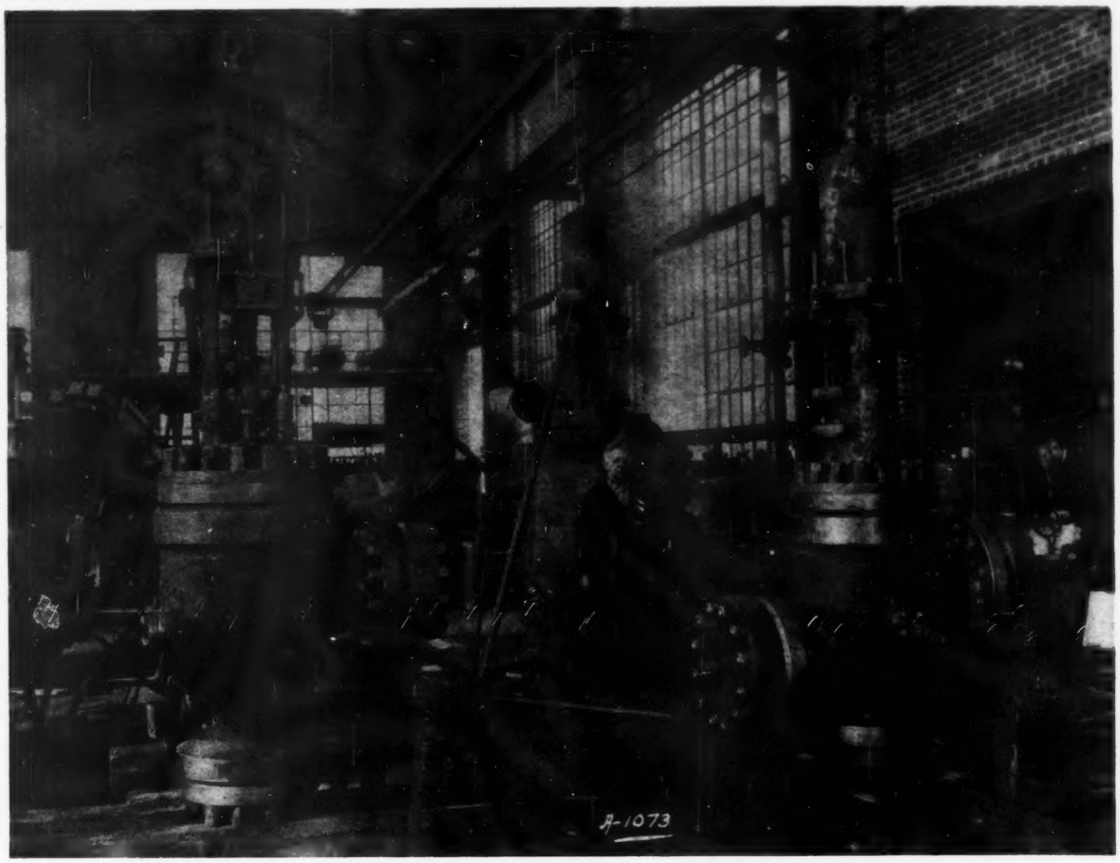
Armstrong Steam Trap Co..................271
Three Rivers, Mich.

Armstrong Machine Works.................271
316 Maple St., Three Rivers, Mich.
Will show their complete line of Cast Iron and Forged Steel Traps as well as a glass model operating under steam and a sectional model of their new Piston Operated or Compound Trap.

Ashton Valve Co...........................38
161–179 First St., Cambridge 41, Boston, Mass.
Ashton Pop Safety and Relief Valves for saturated and superheated steam, water, ammonia and acid service will be exhibited. Also Pressure and Vacuum Gages, and Dead Weight Double Area Gage Testers. Their entire line will be featured.

Continued on page 76

Advertisements of firms listed in color appear on pages indicated



Three S & K Offset Body Turbine Throttle Valves—1200 lbs. working pressure

See our Gear Pump ad on page 145

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Continued from Page 74 **Booth**

Associated Alloy Steel Co....................447
Cleveland, Ohio
Manufacturers of Alloy Steel.

Atwood & Morrill Co....................552–553
Salem, Mass.
Exhibiting four different types of bleeder valves, two different types of relief valves, such as are used for turbine casing relief, condensate discharge traps, adjustable combination regulators, solenoid valves, and several other items.

Automatic Switch Co........................551
154 Grand St., New York, N. Y.
Will exhibit control devices of their manufacture, including automatic transfer and remote control switches, relays, contactors, solenoid operated valves, etc.

Babcock & Wilcox Co........................50
85 Liberty St., New York, N. Y.
Showing examples of new welding technique developed by The Babcock & Wilcox Co. Refractories including B. & W. No. 80 Firebrick in standard weight and light weight classes, as well as B. & W. No. 80 Refractory Insulating Brick, B. & W. No. 80 Refractory Cements and Plastics.

Babcock & Wilcox Tube Co...................50
Beaver Falls, Pa.
Showing polished Nirosta KA2 Tubing; specimens of Nirosta KA2 and other iron-chrome-nickel alloy tubes and pipe; cast chrome iron pipe; iron-chrome-nickle alloy castings; steel tubing; and Toncan tubing.

Badger E. B., & Sons Co 565, 566
63-75 Pitts St., Boston, Mass.
...................See Adv. Page 93
Exhibiting their complete line of Expansion Joints and Copper Hot Water Storage Tanks.

Bailey Meter Co..........................51
1026 Ivanhoe Road, Cleveland, Ohio
............See Adv. Pages 122, 123
Exhibit will consist of power plant metering, control and regulating equipment. On three large steel plate panels there will be mounted Bailey Boiler Meters, Fluid Meters, Temperature Recorders, Multi-Pointer Gages and Remote Indicators. The Bailey Thermo-Hydraulic Feed Water Regulator, which incorporates a fully balanced, tight seating, V-port regulating valve, will be shown. Various drives, switches, valves, contactors and other elements of the Bailey Automatic Combustion Control System will be demonstrated. Photographs, prints, layouts and actual meter chart records made by Bailey Meters will be part of the exhibit.

Baldwin-Duckworth Chain Corporation......479
Worcester, Mass.
Will consist of a display of Baldwin Standard Roller Chains, Block Chains, Steel Replacement Roller Chains, Baldwin Precision Silent Chains, Special Chains and various types of Sprockets.

Ballwood Company....................221–222
30 Church St., New York, N. Y.
(See Midwest Piping & Supply Co.)

Bantam Ball Bearing Co....................266
South Bend, Ind.
Showing a regular line of ball and roller thrust bearings, also special large bearings.

Barco Manufacturing Co.....................247
1801 Winnemac Ave., Chicago, Ill.
...................See Adv. Page 71
Will exhibit Barco Flexible Joints and Barco Lubricated Plug Valves as well as Barco Lubricated Service Cocks. Barco Joints are made in all sizes from 1/4" to 48" and over one million of them have already been sold for pipe lines to provide flexibility to take care of vibration, expansion and contraction as well as movements that may be required. These Joints are made for all pressures and temperatures of metals best suited for the services with which they are to be used. Barco Lubricated Plug Valves are made in all sizes and types and of all material suitable for plug valve services. These Valves are very efficiently and simply lubricated.

Barnes & Jones (Inc.)..................312–313
128 Brookside Ave., Jamaica Plain, Boston, Mass.
Will exhibit appliances used in the installation of Vapor and Vacuum Steam Heating Systems; including Thermostatic Steam Traps for radiators, Modulation Valves, Drip Traps, Blast Traps, Boiler Return Traps, Vent Traps, etc.

Bauer & Black........................477–478
2500 S. Dearborn St., Chicago, Ill.
Will exhibit Surgical and First Aid Supplies for use by Industrials, Public Utilities, etc. Uniflex First Aid Kits, Non-ravel Bandages, Zinc Oxide Adhesive Plaster on spools, and Rack Spool Adhesive for First Aid Rooms.

Bausch & Lomb Optical Co..................602
635 St. Paul St., Rochester, N. Y.
Products to be exhibited and demonstrated will be: Contour Measuring Projector and large photomicrograph apparatus; Toolmaker's Microscope; Optical Comparator; Optical Indexing device; Optical Bevel Protractor; Optical Drill Gage; Thread Profile Gage; and Centering Level. The Latest Shop Microscope of the Bausch and Lomb manufacture will be demonstrated.

Belfield, H., Co..........................550
435 N. Broad St., Phila., Pa.
Exhibiting a new type regulating valve for high pressure and high velocity, especially adapted for oil, cylinder, solenoid and motor operated remote controlled valves. All iron specialties. Schaefer Bypass valve. Regulating valves steel stainless steel trim. Steam jacketed cocks.

Bendix Aviation Corp'n....................429
Baltimore, Md.

Bernitz Furnace Appliance Company.....78
89 Broad St., Boston, Mass.
.....................See Adv. Page 10
The products shown will be the Bernitz S-100 "Carbofrax" air-cooled walls that are extensively used in stoker fired boiler furnaces. Bernitz air-cooled "Carbofrax" floors and walls for pulverized fuel and oil burning furnaces. Bernitz Nygaard coverage for water walls ("Carbofrax" and cast iron types of blocks) and Bernitz super linings for water gas generators. Several new improvements have been made in the Bernitz Nygaard water wall coverage and these will be prominently exhibited.

Biax Flexible Shaft Co. (Inc.)..............508
20 E. 17th St., New York, N. Y.
Showing Flexible Shafts and Flexible Shaft Machinery, Die sinking equipment, Grinders, portable Screw driving equipment, Sanding equipment, portable; Shears, portable; (for sheet metal) Rail grinding equipment portable, also rotary files for die work.

Biglow, L. C., & Co. (Inc.)................266
250 West 54th St., New York, N. Y.
Representing: Bantam Ball Bearing Company, Hanson-Whitney Machine Company, McGill Metal Company, Perkins Machine and Gear Company, and Scully-Jones & Company.

Bijur Lubricating Corp'n..................605
250 W. 54th St., New York, N. Y.
Will exhibit central lubricating apparatus for lubricating the bearings of industrial machinery from a central reservoir. Automatic and hand operated systems will be exhibited.

Bilgram Machine Works (Inc.).........491–492
1235 Spring Garden Ave., Philadelphia, Pa.
The latest improved 6" Bevel Gear Generator will be exhibited, which cuts straight and spiraloid teeth; six (6) to one (1) ratio, eight speeds, belt or motor driven, cuts any pitch or fractional pitch within range of machine, will cut gears at exhibit.

Black & Decker Co...................520–521
Towson, Md.
Will have an operating exhibit of various tools and will feature a display of the complete line of Black & Decker Portable Electric Tools including: Electric Drills; Drill Press Stands; Grinders, Bench and Portable Sanders; Portable Electric Saws; Portable Electric Hammers; Portable Electric Screw Drivers and Nut Reamers; Heavy Duty Grinder and Buffer Lines; and High Cycle Line of Super Power Production Tools.

Black & Decker-Van Dorn.............522–523
Towson, Md.

Black Diamond Saw & Machine Works......644
Natick, Mass.
Will exhibit Circular Saw Filing Machine for filing saws used by electrotypers and soft metal workers. Band Saw Filing Machine for wood cutting saws. Combined Knife and Circular Saw Grinder for wood-working shops.

Boig & Hill (Inc.).........................250
180 Washington St., New York, N. Y.
Representing: Julian d'Este Company.

Boiler Engineering Co....................450
931 Federal Trust Bldg., Newark, N. J.
The Boiler Engineering Co., 24 Commerce St., Newark, N. J., now affiliated with the Plibrico Co., Chicago, will exhibit separately in the same booth heretofore occupied by them—No. 450. Exhibit will make clear the difference between unyielding monolithic boiler baffles and the yielding flexible Beco-Turner Boiler Baffle. Photographs of numerous installations in all kinds of water tube boilers, horizontal and vertical, will be on display.

Bond, Chas., Co..........................561
617 Arch St., Phildelphia, Pa.
Will have on exhibit Bond Stock Gears, Bond Truck Casters, Bond Flexible Couplings, with a further display of Bond Oak tanned and special tanned Bondaron Flat Belt and Bondaron Round Belt, together with a display of textile leather specialties.

Bond Foundry & Mach. Co.................562
Manheim, Pa.
Will exhibit a full line of Power Transmitting Machinery, Anti-friction Bearings and Truck Casters. Truck Caster display will show quite a few new developments in this line together with a moving Exhibit illustrating in an enlarged form, Improved type of Double Ball Race Swivel Truck Caster.

Bonney Forge & Tool Works...........650–651
Allentown, Pa.
Will exhibit (C-V) Chrome Vanadium Wrenches of a large range of varieties and patterns, including open-end Wrenches, Socket Wrenches (both solid and detachable), Double Hex Box Wrenches, Ratchet Wrenches and Stillson Wrenches.

Borden Co............................248–249
350 Dana Ave., Warren, Ohio
Will display their full line of Easy-Cutting Die Stock, Square-End Pipe Cutters and Power Drives.

Boston Gear Works Sales Co. (Inc.)..326–331
North Quincy, Mass.
...................See Adv. Page 127
Will exhibit representative types of Boston Gear stock products of every description, consisting of Gears, Speed Reducers, Reeves Variable Speed Transmission, Renold-Boston and Duckworth-Boston Inverted Tooth and Roller Chain Drives, Doehler-Boston Die-Cast Stock Gears, Curtis Universal Joints, "Nice" Ball Bearings, light transmission parts, etc.

Botfield Refractories Co....................94
Swanson & Clymer Sts., Philadelphia, Pa.
..............See Adv. Pages 118, 119
Exhibit will cover their entire line of refractories products, including ADAMANT Fire Brick Cement, ADACHROME Plastic Super-Cement, ADACHROME Fines and Aggregate, ADAPATCH and the ADAMANT gum. Specimens, showing the application of each product, will be shown.

Bowser, S. F., & Co. (Inc.)................620
Fort Wayne, Ind.
Will have something very interesting in the way of an educational exhibit, showing actual installations of lubricating equipment, in the form of large photographs.

Bradley Washfountain Co.............403–404
2203 Michigan St., Milwaukee, Wis.
One of the latest type foot-controlled Bradley Washfountains, and drinking fountain of the same materials, will be exhibited.

Breuer Electric Mfg. Co...............463–464
844 Blackhawk St., Chicago, Ill.
Will exhibit the following: Tornado Portable Electric Blowers; Tornado Industrial Vacuum Cleaners; Tornado Portable Paint Sprayer; Tornado Heat Blower and Tornado Spring Winder.

Bristol Company............................12
Waterbury, Conn.
Will have on demonstration a complete line of Indicating and Recording Instruments including Pressure and Vacuum Gauges, Thermometers, Voltmeters, Ammeters, Wattmeters, Shunt Ammeters, Differential Recorders, Control Valves, etc. Features of special interest will include Electrical Instruments of improved design and models. Also Air Operated Draft Controller.

Brooklyn Boro Gas Co........................7
Coney Island, N. Y.
See American Gas Association (Inc.)

Brooklyn Union Gas Co......................7
180 Remsen St., Brooklyn, N. Y.
See American Gas Association (Inc.).

Browne, A. L..............................83
New York, N. Y.

Brown Instrument Co.......................49
4486 Wayne Ave., Philadelphia, Pa.
...................See Adv. Page 77
An interesting and educational display will be

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Continued from Page 76 **Booth**

the feature of the exhibit which will consist of a Brown Electric Flow Meter Manometer and indicating and recording instruments measuring flow through a pipe circuit, part of which is made of glass. Another feature is a sectional view of a Brown Flow Meter Manometer. The above display will occupy the central panel of a modern instrument board containing four other sections, respectively featuring Brown Thermometers for power plant temperature records, Brown Pyrometers for stack and furnace temperatures, Brown Flow Meters for steam, water, air, oil and gas flows, and Brown Recording Gauges for pressure, liquid level, CO_2 and other miscellaneous operating factors in power plant efficiency. The thermometer panel will display both resistance and pressure type Brown Thermometers. Included in the pyrometer display will be indicating and recording pyrometers. Flow meter instrument panels will carry the Brown Indicating model and the Brown Circular Chart Recorder; also Brown Strip Chart Recording Flow Meters of the single record and duplex types.

Brunswick-Kroeschell Co.....................14A
4221 Diversey Ave., Chicago, Ill.
See Carrier Corp'n

Buffalo Forge Co.....................413–414
490 Broadway, Buffalo, N. Y.
....................See Adv. Page 87

Exhibit will include many new and interesting developments. A full size rotor from one of the induced draft fans which will be furnished Waukegan Generating Station will be exhibited. The new Buffalo gas unit heater will be exhibited. This unit is compact, arranged for suspension and complete with safety features and controls. The new Model "B" Breezofin Steam unit heaters with latest design of fin type radiation will be exhibited. A new line of single stage compressor blowers will be exhibited as well as several other pieces of equipment which will be of general interest. One of the new designs of single stage centrifugal pumps will be exhibited by their associates, The Buffalo Steam Pump Company.

Builders Iron Foundry.....................28
19 Codding St., Providence, R. I.
Will show Venturi Meters and Shunt Meters for steam, air and gas. In addition will display the brand new Builders Electric Flow Meter.

Building Specialties Co. (Inc.)..244–245, 283–284
22 Clinton St., Brooklyn, N. Y.
Manufacturers of Heating Units.

Bundy Steam Trap Co.....................8
39 Elm St., Nashua, N. H.
Showing a complete line of Bundy Traps and their application.

Campbell, Andrew C. (Inc.)............344–345
Bridgeport, Conn.
Exhibit will show the uses and users of Campbell Nibbling Machines and will have four machines in actual operation cutting parts from steel.

Carborundum Co.....................22
Niagara Falls, N. Y.
Exhibit of the Refractory Division of the Carborundum Company will consist of the following: Photographic and actual reproduction showing "Carbofrax" brick utilized in solid, water cooled and air cooled walls. "Carbofrax"—Carborundum Brand Silicon Carbide and Aloxite Brand electrically fused aluminum oxide refractory brick, tile, special shapes and high temperature refractory cements.

Carpenter Tool Co.....................644
Barrington, R. I.

Carrier Corp'n.....................14-A
850 Frelinghuysen Ave., Newark, N. J.
....................See Adv. Page 121

Will exhibit the latest technical developments of its three divisions. A special feature of the Carrier Engineering Corporation's display will be their new G-3 Centrifugal Refrigerating machine (representing two years' development in collaboration with the General Electric Company), the smallest of its type in existence. Other exhibits will include a radically different unit air conditioner and the 1931 Weathermaker, a product of the Carrier-Lyle Corporation, manufacturers of air conditioning equipment for the home. The York Heating & Ventilating Corporation will display both floor type and suspended model unit heaters. The Brunswick-Kroeschell Company will exhibit a complete two (2) ton Ammonia refrigeration machine and the Compressor only of their CO_2 variety. The Aerofin Corporation will display their latest developments in copper non-corrosive fan blast heaters.

Carrier-Lyle Corp'n.....................14A
850 Frelinghuysen Ave., Newark, N. J.
See Carrier Corp'n

Cash, A. W., Co.....................273
Decatur, Ill.
Exhibiting Cash Standard Reducing and Regulating Valves.

Celite Products Co.....................14
1320 So. Hope St., Los Angeles, Cal.
See Johns Manville (Inc.)

Centrifix Corp'n.....................203
3029 Prospect Ave., Cleveland, Ohio
Will exhibit line of purifying equipment for steam, vapor, gas and air.

Century Electric Co.....................540–541
1806 Pine St., St. Louis, Mo.
....................See Adv. Page 113

Will exhibit single phase, polyphase, and direct current motors; also split phase, repulsion start induction, squirrel cage and slip ring motors, ranging between the sizes of $1/_{40}$ to 250 horse power. Will also exhibit portable, ceiling, and ventilating fans both alternating and direct current.

Chapman Valve Mfg. Co.....................46–47
203 Hampshire St., Indian Orchard, Mass.
....................See Adv. Pages 102, 103

Exhibiting Chapman Chrome Nickel Steel Gate Valves for high pressure high temperature service and a working model of the Chapman motor unit showing the latest developments in that type.

Chicago Pipe Thread Mach. Co.....................529
Racine, Wis.
Manufacturers of Pipe Threading Machinery.

Chicago-Wilcox Mfg. Co.....................272
E. 77th St., & Anthony Ave., Chicago, Ill.
Exhibiting Wilcox Self-Sealing Gaskets.

Chisholm Moore Hoist Corp'n.....................526
Tonawanda, New York
Exhibit will include: New "HI-UP" Electric Hoist designed for application in limited headroom; "Cyclone" Electric Chain Hoist for universal hoisting service; "Cyclone" Ball Bearing Hand Power Chain Hoist; "Matchless" Timken Bearing Trolley; and "Moore" Ball Bearing Trolley.

Cities Service Oil Co.....................418
60 Wall St., New York, N. Y.

Clements Mfg. Co.....................563
601 Fulton St., Chicago, Ill.
Displaying a complete line of Portable Electrical Industrial Blowing and Suction Cleaning and Spraying equipment.

Cleveland Worm & Gear Co.....................93
3264 E. 80th Street, Cleveland, Ohio
Will exhibit standard Cleveland Worm Gear Reduction Units of various sizes and types in operation. Also standard Cleveland Worms and Gears.

Cling Surface Company.....................511
1032 Niagara St., Buffalo, N. Y.
Will exhibit a 4 kilo-watt generator driven by a $7^1/_2$ h.p. motor through a system of belts, treated with Cling-Surface and running without tension, comparing them to similar belts, untreated.

Clipper Belt Lacer Co.....................265
974–1014 Front Ave., N. W., Grand Rapids, Mich.
The entire Clipper Line, consisting of Clipper belt lacers, belt hooks, belt cutters with safety features, and Clipper connecting pins, will be shown. A feature will be the Clipper Speed lacers Nos. 6 and 8.

Coats Machine Tool Co., (Inc.).....................241
110 West 40th St., New York, N. Y.

Cochrane Corporation.....................67
3142 N. 17th St., Philadelphia, Pa.
Will exhibit the following apparatus: Two Tandem One-Steel Boiler Blow-Off Valves; A Forged Steel Discharger, or High Pressure Trap, discharging large quantities of water under high steam pressure; A Multiport Drainer, which is a low pressure steam trap for handling very large volumes; and a Fig. 1000 Multiport Back Pressure Valve.

Colby, A. C., Mchry. Co.....................401
183 Centre St., New York, N. Y.
Representing: South Bend Lathe Works.

Colson New York Branch (Inc.).....................506
7 East 19th St., New York, N. Y.
Will consist of casters for every purpose. This will include furniture casters with wheels as small as 1" in diameter to heavy truck casters with wheels as large as 8".

Columbus McKinnon Chain Corp'n.....................526
Tonawanda, N. Y.
Manufacturers of Chains for Blocks and Sprocket Wheels.

Combustion Engineering Corp'n.....................23–25
200 Madison Ave., New York, N. Y.
....................See Adv. Page 68

Exhibit will contain the following equipment. Sectional headers for 1400 lb. pressure, a welded drum, samples of welded bends, a section of the C-E Return Bend Economizer, one of the pressed heads for installation at the Brooklyn Edison Company, model of C-E Air Preheater and the new C-E Stoker Unit for small boilers. The C-E Stoker Unit model will be complete showing the agitating grates, dump grates and automatic ash ejector. Large panels showing the Combustion Engineering High Pressure Units and other interesting installations will be a part of the exhibit.

Connery & Co. (Inc.).....................43
2nd & Luzerne Sts., Philadelphia, Pa.
The products to be exhibited are Connery's Improved Expansion Stiffener, showing its application in connection with breechings and duct work; Connery's Air Cooled Damper; Connery's Improved Expansion Stack Connection.

Consolidated Gas Co. of N. Y.....................7
4 Irving Place, New York, N. Y.
See American Gas Association (Inc.)

Consolidation Coal Company.....................628–629
15 Broad St., New York, N. Y.
Exhibit will include a complete showing of bituminous coals mined and sold by them from the Maryland, West Virginia, Eastern Kentucky and Pennsylvania districts.

Cooper, A. C., Sales Co.....................403–404
122 E. 42nd St., New York, N. Y.
(See Bradley Washfountain Company.)

Cooper Hewitt Electric Co. (Inc.).....................4
410 Eighth St., Hoboken, N. J.
Will exhibit Kon-nec-tors (mercury switches) and Neon Glow Lamps. The Kon-nec-tors will be in operation on sign flashers and an automatic pressure control. The Neon Glow Lamps will be in operation as indicator and pilot lights.

Crandall Packing Co.....................527
Palmyra, N. Y.
Exhibit will consist of a complete line of rubber, asbestos and semimetallic packings for all mechanical purposes, especially steam, water, gas, air, ammonia, acids and so forth. Also a new lubricant known as Luball which is supplied both in bulk as well as in the manufacture of packings.

Crane Packing Co.....................261–262
1820 Cuyler Ave., Chicago, Ill.
....................See Adv. Page 85

Will display all forms of Flexible Metallic Packing and Semi-Metallic Packing, as well as Metallic Condenser Packing. Will exhibit a model showing a small condenser equipped with the new "John Crane" Process, whereby ferrules can be eliminated. This model is designed to show operating engineers how air is entrapped in a condenser, and how it can be eliminated by the "John Crane" Process.

Crew-Levick Company.....................418
400 N. Broad St., Philadelphia, Pa.
Exhibit will show display of lubricants in bottles and jars. Likewise will have a large old fashioned anvil with a blacksmith in person. Will have an electric arrangement on top of anvil showing sparks similar to that when blacksmith hammers heated iron.

Crosby Steam Gage & Valve Co.....................44-B
40 Central St., Boston, 8, Mass.
Exhibiting a complete gage board assembly consisting of five (5) panels containing fifteen (15) flush mounted instruments. The instruments will consist of single spring pressure, indicating and recording gages, hydraulic gages, test gages, double screwed tube pressure gages, clock and engine revolution counter. Will also exhibit a high pressure and temperature nozzle type pop safety valve of latest design.

Dampney Company of America.....................62
Hyde Park, Boston, Mass.
Will exhibit their complete line of APEXIOR Protective Coatings for metal surfaces and show the equipment that has been developed for applying same expeditiously to the internal surfaces of boiler, economizer and condenser tubes, etc.

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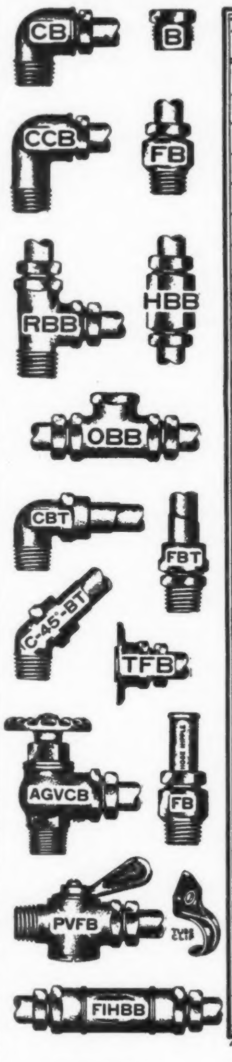
Advertisements of firms listed in color appear on pages indicated

Standard Shapes

(Decimal Equivalents and Areas of Circles)

Parker Appliance Co.~10320 Berea Rd.~Cleveland, O.



Fractions or Dia.	Decimal Equiv.	Areas of Circles	Fractions or Dia.	Decimal Equiv.	Areas of Circles
1/64	.0156	.0002	33/64	.5156	.2088
1/32	.0312	.0008	17/32	.5312	.2217
3/64	.0468	.0016	35/64	.5468	.2349
1/16	.0625	.0031	9/16	.5625	.2485
5/64	.0781	.0048	37/64	.5781	.2624
3/32	.0937	.0069	19/32	.5937	.2769
7/64	.1093	.0093	39/64	.6093	.2916
1/8	.125	.0123	5/8	.625	.3068
9/64	.1406	.0154	41/64	.6406	.3223
5/32	.1562	.0192	21/32	.6562	.3382
11/64	.1718	.0231	43/64	.6718	.3545
3/16	.1875	.0276	11/16	.6875	.3712
13/64	.2031	.0323	45/64	.7031	.3883
7/32	.2187	.0376	23/32	.7187	.4057
15/64	.2343	.0431	47/64	.7343	.4235
1/4	.25	.0491	3/4	.75	.4418
17/64	.2656	.0553	49/64	.7656	.4604
9/32	.2812	.0621	25/32	.7812	.4794
19/64	.2968	.0691	51/64	.7968	.4987
5/16	.3125	.0767	13/16	.8125	.5185
21/64	.3281	.0845	53/64	.8281	.5386
11/32	.3437	.0928	27/32	.8437	.5591
23/64	.3593	.1013	55/64	.8593	.5800
3/8	.375	.1105	7/8	.875	.6013
25/64	.3906	.1198	57/64	.8906	.6229
13/32	.4062	.1296	29/32	.9062	.6450
27/64	.4218	.1398	59/64	.9218	.6675
7/16	.4375	.1503	15/16	.9375	.6903
29/64	.4531	.1612	61/64	.9531	.7134
15/32	.4687	.1726	31/32	.9687	.7371
31/64	.4843	.1842	63/64	.9843	.7610
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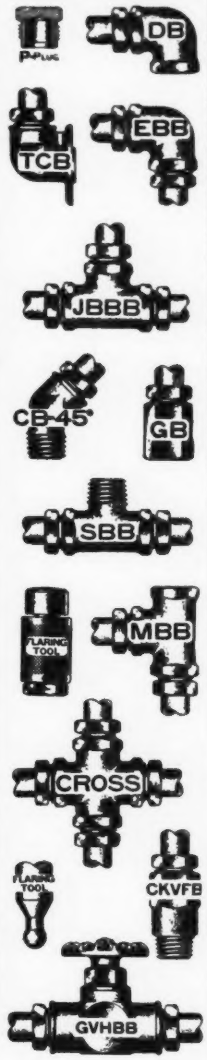

PARKER
·TUBE·COUPLINGS·

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PARKER Products are famous in every industry where Pipe is used. Nowhere has the superiority of PARKER Heavy Duty Fittings been so thoroughly demonstrated as in American Power Plants.

PARKER Copper Plumbing is found in the largest public utility and the smallest industrial Plant always serving faithfully in this most difficult service.

(Send for literature)

PARKER APPLIANCE CO.

The above chart printed in two colors on good ledger stock will be sent free on request. Attach this clipping to letterhead.

Wall Chart 16" x 22"
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Binder size 4¼" x 7⅛"

Check sizes desired.

Ninth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108* Booths No. 401 to 656—Third Floor—*Diagram on Page 110*

Continued from Page 78 **Booth**

Dardelet Threadlock Corporation........296–297
120 Broadway, New York, N. Y.
Exposition of the Dardelet Thread as applied to nuts and bolts. Various applications of the thread. Taps, dies, chasers and tools for Dardelet thread cutting. Samples of manufacture by licensees of the company.

Davis Boring Tool Co......................266
St. Louis, Mo.
Division of the Larkin Packer Company, St. Louis, Mo. Manufacturer of Davis Improved Type "L" Micrometer Expansion Boring Tools, Multiple Head Boring Tools, Expansion Reamers, Plain and Expanded Block Type Bars and Cutters for car wheel, railroad and general industrial boring.

Dean, Payne (Ltd.).........................16
17 East 45th St., New York, N. Y.
(See Limitorque Corporation.)

Dearborn Chemical Co......................13
310 S. Michigan Ave., Chicago, Ill.
Copies of their new book, entitled, "Scientific Water Correction" will be distributed to those interested in treating of boiler feed water supplies and will also have other interesting and descriptive circulars regarding water treating preparations. Samples of their various consistencies of No-Ox-Id Rust Preventive will be exhibited.

De Bothezat Impeller Co...............423–424
1922 Park Ave., New York, N. Y.
Will exhibit Disc Pressure Fans all sizes 8"–8'. Bifurcators, unit heaters of unusual design, Impeller Blowers, Disc Blowers, also a demonstration of possibility of obtaining non-overloading characteristics and high static pressure with very high efficiency with a Disc Fan of Dr. G. de Bothezat's special design.

deSanno, A. P., & Son......................459
1615 McKeen St., Philadelphia, Pa.
Types "C" and "D" Radiac Cut-Off machines will be exhibited and demonstrated.

d'Este, Julian, Co.........................250
Cambridge & Spice Sts., Boston, Mass.
Will exhibit the CURTIS ENGINEERING SPECIALTIES. They will include stock and sectioned models of Pressure Reducing Valves for steam, water, air and gas; Combustion and Damper Regulators; Steam Drainage Traps, etc.

Detroit Seamless Steel Tubes Co...........229
Detroit, Mich.
Manufacturers of SEAMLESS STEEL TUBING for Railroads, Industrial Plants and Marine boiler purposes and also manufacturers of SEAMLESS STEEL TUBING for all Mechanical purposes.

DeWalt Woodworking Machinery Corp'n....655
1775 Broadway, New York, N. Y.
Manufacturers of Woodworking, Metal Cutting, and Marble Cutting Machinery.

Diamond Chain & Mfg. Co.............316
401 Kentucky Ave., Indianapolis, Ind.
See Adv. Page 100
Two tables of running Diamond High Speed Roller Chain Drives, consisting of both single and multiple strand, will be exhibited along with samples of the various special attachments which we manufacture, also models of the Diamond Clark Flexible Couplings.

Diamond Power Specialty Corp'n..........16–17
10340 Oakland Ave., Detroit, Mich.
Will feature Diamond High Pressure Gauge Glasses "Loose Window" and Water Columns. Full size apparatus cut away to show working parts and a glass and column in operation will be displayed. Will also show the latest developments in soot blower apparatus.

Dixon, Jos., Crucible Co...................254
Wayne & Monmouth Sts., Jersey City, N. J.
Will exhibit Graphite Products applicable to the generation and transmission of power such as Flake Lubricating Graphite, Graphite Greases of all kinds, Belt Dressings, etc. Also Dixon's Industrial Paint for the protection of all metal surfaces.

Dri-Steam Valve Sales Corp'n........209A, 210
70 E. 45th St., New York, N. Y.
Exhibit will consist of a complete line of Dri-Steam Valves for power plants, marine boilers and locomotive boilers. Also, small size valves for auxiliary steam lines and air lines. It will also include a new development of drier for locomotive installations.

Dry Quenching Equipment Corp'n............24
200 Madison Ave., New York, N. Y.
See Combustion Engineering Corporation.

Booth

Dunn, Struthers (Inc.)......................528
139 N. Juniper St., Philadelphia, Pa.
Will exhibit the following equipment: Relays, Remote control, Thermostatic Devices, Electrical melting pots, and Ladles, Insulating Fish Spine Beads. Also, our thermo-regulator in operation which will respond to temperature variations of $^1/_{10}$ of a degree.

Eastern Refractories Co....................27
10 T Wharf, Boston, Mass.
(See S. Obermayer Company.)

Economy Lubricating Co....................448
Charlestown, Massachusetts
Showing samples of "True Blue" a successful guaranteed boiler treatment and samples of Economy Grease, a lubricant of the better grade.

Edison Storage Battery Co..................616
Orange, N. J.

Electric Storage Battery Co................428
Allegheny Ave., at 19th St., Philadelphia, Pa.
Will have on display batteries designed for various purposes in the power plant field.

Electrical Manufacturing...................434
461 Eighth Ave., New York, N. Y.
Display will be focused upon that true electrical manufacturer, the maker of motor-equipped machinery; also upon the exclusive editorial service Electrical Manufacturing renders him.

Electrical Record..........................434
461 Eighth Ave., New York, N. Y.

Electro Anti-Corrosive Corp'n..............481
140 Cedar St., New York, N. Y.
Exhibit consists of literature and diagrams explaining the Kirkaldy Electrolytic Protective System. Kirkaldy Electrolytic Protective System reveals long needed development for prevention of corrosion and scale deposits on water surfaces of boilers, heaters, and condensers.

Electrocon Corporation....................610
6 Varick Street, New York, N. Y.
Showing the Davey Portable Balancing Equipment for balancing rotating machinery in service. A simply operated device by which machines of any size or speed may be balanced under actual operating conditions. Also the Vibroscope, for observing high speed mechanisms while in motion.

Ellison Draft Gage Co......................45
214 West Kinzie St., Chicago, Ill.
Exhibiting 34-Pointer Draft Gage, Straight-Line Movement, Differential, for the new forced draft Taylor stoker with Venturi nozzle in the Wind-box, 1-Pointer for each nozzle. Also Ellison Pointer Draft Gage, Straight-Line Movement, with Tilted scales for high mounting. Also Ellison check seal for sealing Pointer Draft Gages from drawing out the oil under draft in excess of the scale range without increasing the height of the gage.

Engberg's Electric & Mechanical Works....15-B
Troy, Pa.
(See Troy Engine & Machine Co.)

Engineering (Ltd.)........................407
135–36 Bedford St., Strand, London W. C., England
Copies of Engineering containing 1929 Power Show discussions, and inserts or plates conveniently arranged illustrating (often with detail drawings) important engineering undertakings throughout the world—including drawings of R-101—will be shown.

Engineering & Finance........"A" Main Floor
551 Fifth Ave., New York, N. Y.
A monthly publication, founded in 1919 as Combustion, renamed in 1929, devoted to the interest of the combustion engineer and utility executive.

Engineering Publications (Inc.).........421–422
1900 Prairie Ave., Chicago, Ill.
Will exhibit Heating, Piping and Air Conditioning, a monthly technical journal for Consulting and Maintenance Engineers of these respective fields.

Ernst Water Column & Gauge Co...........76
44 Oakland Terrace, Newark, N. J.
Exhibiting Water Column Equipment for high steam pressures. The improved "Split-Gland" Water Gages which have no Gage Glass Packing Nuts, with a Guard which permits the use of tubular Glasses for pressures up to 650 pounds economically and with absolute safety.

Evans Elevator Equalizer Co..............2-E
Bedford, Ind.

Booth

Everlasting Valve Company...................41
1 Exchange Place, Jersey City, N. J.
Main Features of the Exhibit: Regular Everlasting Valves; Everlasting's Companion Angle Valve; Everlasting Special Water Column Valve and Everlasting Duplex Blow-off Unit.

Fafnir Bearing Company 246
New Britain, Conn.
Exhibit will include a complete display of Ball Bearings of all types and sizes, Ball Bearing Power Transmission Equipment, etc. This comprises in the main, Single Row Bearings, Double Row Bearings, Thrust Types, Angular Contacts, separable designs, Self-Aligning Heavy Duty, and Capacity Bearings in general.

Fairbanks Co............................232–233
Broome & Lafayette Sts., New York, N. Y.
Products to be shown: Bronze and Iron Body Valves. Main feature of the exhibit will be the Fairbanks New Sphero Valve, electrically operated.

Federal Gauge Co.....................215–216
564 W. Adams St., Chicago, Ill.
Manufacturers of Pressure Gages, Vacuum Gages, Liquid Level Controls, Electrically Operated Pressure Regulators, and Electric Thermostats.

Ferner, R. Y., Co......................402–403
Investment Bldg., Washington, D. C.
Representing: Triplex Machine Tool Co.

Fisher Publishing Co.......................621
299 Madison Ave., New York, N. Y.

Foley Manufacturing Co....................451
11 Main St., N. E., Minneapolis, Minn.
Exhibiting the Foley Automatic Saw Filer—The Three Way Machine, files and joints in one operation, hand, band, and circular saws.

Foote Bros. Gear & Machine Co............3-F
111 N. Canal St., Chicago, Ill.
Exhibiting the following: $7^1/_2$ WB New Style Antifriction type medium duty Reducer, Ratio 29:1; 4HGX Hygrade Reducer—Standard HGX antifriction type bearing worm Reducer, Ratio 93:1, with set of helical gears mounted on worm shaft to be used on reduction ratios between 50.1 and 100:1; 4 HGB Special Vertical Worm Reducer special oiltight construction; and 4 SX Titan Helical Speed Reducer, Ratio 5.32:1.

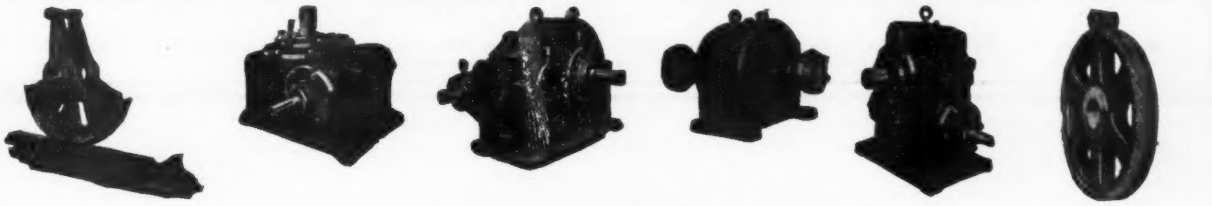
Foster-Wheeler Corpn.................77, 91
165 Broadway, New York, N. Y.
See Adv. Pages 100, 101
Exhibit will consist of full sized sections, models and samples of construction covering air heaters, superheaters, economizers, heat exchangers, pulverized fuel equipment, steam jet vacuum pumps, expansion joints, and water cooled furnace surfaces. Of particular interest will be the full sized cut-away section of a plate type air heater, sections of round tube alloy steel radiant superheaters, and pulverized coal equipment. A sample board of brass and copper tubing will also be on display and a complete set of enlarged photographs and drawings will cover installations of complete steam generating units, waste heat boilers, muffler boilers, condensers, feed water heaters, evaporators, and associated power plant apparatus.

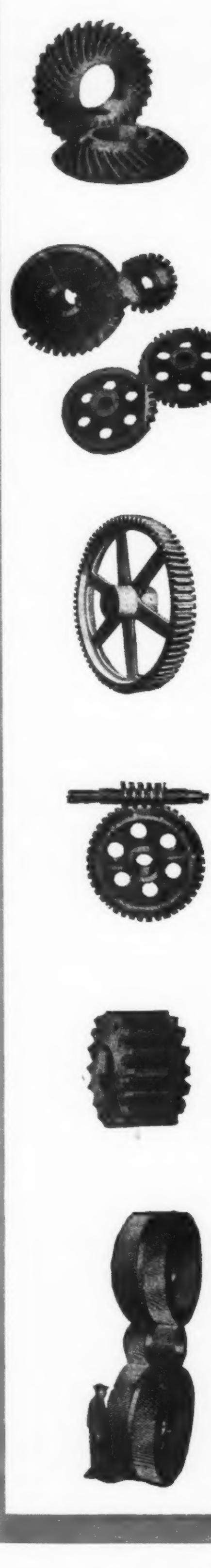
Foxboro Co. (Inc.)....................411–412
Foxboro, Mass.
Will exhibit a complete line of Power Plant Instruments for Indicating, Recording and Controlling Temperature, Pressure and Flow. In addition and of special interest will show a new Flow Meter for pressures up to 2500 lb. per sq. inch.

Fuller-Lehigh Co.........................54–55
Fullerton, Pa.
See Adv. Pages 98, 99
Exhibit will show the grinding elements of the new Fuller Lehigh Type B Pulverizer. It is an air-separation ball mill and retains all the desirable features of the well-known Lehigh Mill including the spherical ball and grinding ring principle in which fineness is not affected by wear of parts that required lubrication. There will also be exhibited a large illuminated shadow-box in which is mounted a cross-sectional wash drawing of the new pulverizer. In order to show drawings and photographs of some 50 Fuller Lehigh installations of Pulverized-Coal Equipment and Bailey Water-Cooled Furnace Walls, a special displayor will be used giving some interesting facts regarding each of these installations.

Continued on page 82

Advertisements of firms listed in color appear on pages indicated





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Continued from Page 80 **Booth**

Fulton Sylphon Company...............219–220
Knoxville, Tenn.
Showing Sylphon Temperature and Pressure Regulators and Steam Specialites including regulators for water tanks, liquid baths, dryers, air ducts, room spaces and refrigeration. Principal Heating Specialties include Automatic Radiator Valve for thermostatic control of rooms, packless Expansion Joints for heating risers, Pressure Regulators and Damper Regulators for steam boilers.

G. D. S. Shearing & Punching Mch. Co...635–636
2 Lafayette St., New York, N. Y.
Will exhibit a complete line of steel plate hand and power operated shearing and punching machines, barcutters and bar-benders.

G&G Atlas Systems (Inc.)...............86–88
537 West Broadway, New York, N. Y.
Will exhibit pneumatic tubes for handling mail, telegrams and interoffice documents among scattered departments in a building.

Gage Publishing Co.......................434
461—8th Ave., New York, N. Y.

Garlock Packing Co....................545–546
Palmyra, N. Y.
Will exhibit a complete line of fibrous and metal packings and gaskets. The exhibit will feature Garlock Chevron Packing—a patented automatic packing for severe service conditions—and Garlock Buttonhole Tape—a new asbestos gasketing material with individual features.

Gears & Forgings (Inc.)...............554–555
3130 Woodhill Rd., Cleveland, Ohio
See Adv. Page 111
Will exhibit Speed Reducers—planetary, worm and herringbone gear types; Reduction Drives—2–3 speed stoker, etc.; Gears—heat treated, case hardened, etc.; and Forgings—drop, tool and hammered.

General Electric Co.......................4–5
Schenectady, N. Y.
Exhibit will include various types of new motors and control; a new switch house and miniature switchboard; a rapid and accurate electric gauge; and a colorama demonstration using the new selsyn thyratron control.

General Electric Vapor Lamp Co.............4
Hoboken, New Jersey
Will exhibit Kon-nec-tors and Mercury Switches, operating in various controls and apparatus, as well as Neon Glow Lamps as pilot and indicator lights. There will also be a demonstration of Cooper Hewitt Industrial Lighting.

General Fire Extinguisher Co...............309
420 Lexington Ave., New York, N. Y.
Manufacturers of fire extinguishing equipments.

General Insulating & Mfg. Co..........465–466
Alexandria, Ind.
Exhibiting the following: Gimco Rock Wool Flexfelt for Heat, Cold and Sound Insulation, Pipe Covering for heat and cold insulation, Rock Wool Corkboard and Loose and Granulated Rock Wool.

Gillis & Geoghegan (Inc.)................86–88
537 West Broadway, New York, N. Y.
Will exhibit G&G Telescopic Hoists for removing ashes, garbage and rubbish from buildings. Electric and hand power models will be in operation.

Girtanner Engineering Corp'n..............205
Palmyra, N. J.
Will exhibit general engineering data, photographs, etc., covering special features of Ash Handling equipment, new style Dust Collector and general installations. Will also exhibit a line of high abrasive White Iron and special abrasive resisting castings in difficult shapes.

Gits Bros. Mfg. Co.......................452
1846 S. Kilbourne Ave., Chicago, Ill.
Will exhibit their complete line of oil seal rings, oil cups and lubricating devices.

Gleason, J. L., & Co......................618
207 Bent St., Cambridge, Mass.
Will exhibit Hand and Spring Reels, connecting Stations and Plugs, for power application, also prints and photos and prints of large Motor Driven Reels. An interesting feature will be collectors for large Reels, for large power and 2300 volt power.

Gordon, James, T., Co..................92–93
11 Park Place, New York, N. Y.
Representing: Cleveland Worm & Gear Company, Andale Company, American Flexible Coupling Company and W. H. Nicholson & Company.

Booth

Greenfield Tap & Die Corp'n...............461
Greenfield, Mass.
Exhibit will consist of various displays illustrating the seven major GTD lines: screw plates, taps, dies, reamers, twist drills, gages and pipe tools.

Green Fuel Economizer Co...............72–73
Beacon, N. Y.
See Adv. Page 105
Will exhibit Forced Draft Fan, Induced Draft Fan and Working model of Cindertrap.

Grinnell Co. (Inc.).................308–311
216 North Exchange St., Providence, R. I.
Will exhibit: Thermolier (Unit Heaters); Pipe Bending and Welding; Grinnell Adjustable Pipe Hangers; Grinnell Fittings; Thermoflex Traps; and Grinnell Unit Cooler and Liquid Level Control.

Griscom-Russell Co.......................44A
285 Madison Ave., New York, N. Y.
Will feature in their exhibit two developments which have been perfected during the past year. The first of these is the G-R Equaflo Heat Exchanger. Will also exhibit their new G-Weld.

Hammar Company (Inc.)....................603
17 State Street, New York, N. Y.
Will exhibit gears using Hammar Tooth Forms. The exhibit will feature the comparative size of gears with their tooth form and especially stress the ability to use pinions of low tooth numbers.

Hanson-Whitney Machine Co.................266
169 Bartholomew Ave., Hartford, Conn.
Showing their small tools, including ground thread taps, finished after hardening, and also various types of thread gages.

Harbison-Walker Refractories Co............58
Farmers Bank Bldg., Pittsburgh, Pa.
Will exhibit specimens of first quality and second quality fireclay brick produced in various manufacturing districts; also, high alumina brick which are also coming into greater favor for power plant boiler settings. There will also be samples of Magnesite, Chrome, Metalkase and Duro Acid-Proof brick, Thermolith and Firebond high temperature cements and samples of raw materials from which the various types of refractories are made.

Hartzell Propeller Co.....................211
Piqua, Ohio
Will display units varying in size from 12" to 60", including not only various sizes of wall type exhaust fans, but also extension shaft units, Kool Blast Fans for man-cooling purposes, etc.

Hays Corp'n............................81–82
Michigan City, Ind.
Exhibiting CO_2 Recorders and Draft Gauges—Combustion Testers, Gas Analysers.

Hazard Insulated Wire Works..............619
Pittsburgh, Pa.
(See Okonite Company.)

Heat and Power of Canada.................621
95 King St., E. Toronto, Canada
Exhibiting Heat and Power of Canada and FISHERS' MACHINERY GUIDE, serving the steam and electric power and machine tool and industrial fields, respectively, in Canada.

Heat Transfer Products (Inc.)........338–339
30 Church Street, New York, N. Y.
See Adv. Page 96
Exhibit will consist chiefly in a display of enlarged photographs of H. T. P. products relating to power plant equipment. Appropriate literature will be distributed, and representatives will be on hand to answer questions.

Heating, Piping & Air Conditioning.....421–422
110 East 42nd St., New York, N. Y.

Heating & Ventilating....................480
521 Fifth Avenue, New York, N. Y.
Exhibiting copies of Heating and Ventilating, copies of The Heating and Ventilating Degree-Day Handbook (used for estimating fuel consumption in heating plants) and other textbooks.

Hedges-Walsh-Weidner Co...................25
Chattanooga, Tenn.
(See Combustion Engineering Corp'n)

Heine Boiler Co...........................24
St. Louis, Mo.
(See Combustion Engineering Corp'n)

Booth

Hill, E. Vernon, Co.......................607
121 N. Clark St., Chicago, Ill.
Will exhibit a complete line of air testing instruments including Pitot tubes and gauges, psychrometers and wet and dry instruments, dust counters, draft gauges, Complete Air Test Cases.

Hill Clutch Mch. & Foundry Co.............634
Cleveland, Ohio

Hisey-Wolf Machine Company.........340–341
Cincinnati, Ohio
Exhibit will consist of Electric Drills, Grinders and Buffers.

Hitchcock Company........................274
48 Pearl St., Boston, Mass.
Manufacturers of Anti-Corrosive Rubber Compound.

Houghton, E. F., & Co................532–534
240 W. Somerset St., No. Phila., Pa.
Exhibit will feature Houghton Power Transmission and Lubricating Service. The Houghton Pullmeter will be one of the main attractions.

Howell Electric Motors Company...........441
17 East 42nd Street, New York, N. Y.
Exhibit will consist of the following: Standard Squirrel Cage Polyphase Motor; Vertical Squirrel Cage Polyphase Motor; Fully Enclosed Fan Cooled Polyphase Motor; Condenser Type Single Phase Motor (standard); and Condenser Type Single Phase Motor for Farm Duty.

Hutchinson Mfg. Co..................630–631
Norristown, Pa.

Huyette, Paul B., Co....................81–82
5 South 18th St., Philadelphia, Pa.
Representing: National Regulator Co., High Pressure Damper Regulators; Reliance Gauge Column Co., Gauge Glasses; Hays Corporation, CO_2 Recorders and Draft Gauges, Combustion Testers, Gas Analysers; Cochrane Corporation, Flow Meters; and PBH Water Gauges and Gauge Cocks.

I-T-E Circuit Breaker Company.........624–625
19th & Hamilton Sts., Philadelphia, Pa.
Showing typical Multumite safety steel-enclosed three panel switchboard including a bus tie section.

Illinois Engineering Co..................83–84
Racine Ave. at 21st St., Chicago, Ill.
Exhibit will consist of a brilliantly illuminated shadow box containing the samples of our heating system and power plant specialties, some in cross sections; the set-up of a panel board and three full size zone control valves, illustrating the operation of the Illinois Zone Control Systems of heating.

Imperial Coal Corp'n.......................36
295 Madison Avenue, New York, N. Y.
The exhibit this year will feature high grade bituminous industrial coals and their preparation to meet the various needs of industry, including the proper sizing, cleaning and dustproofing.

Industrial Controller Co..................442
Milwaukee, Wis.
(See Square D Co.)

Industrial Power.........................405
608 S. Dearborn St., Chicago, Ill.
Exhibit will consist of sample copies of Industrial Power and trade promotional literature.

Instant Water Heater Sales Div.............273
332 S. Michigan Blvd., Chicago, Ill.
Exhibit will consist of cut out sectional view of typical heater showing arrangement of two interior copper pipes which comprise the heating element.

International Combustion Engineering........23
200 Madison Ave., New York, N. Y.

International Engineer....................569
1003 "K" St. N. W., Washington, D. C.

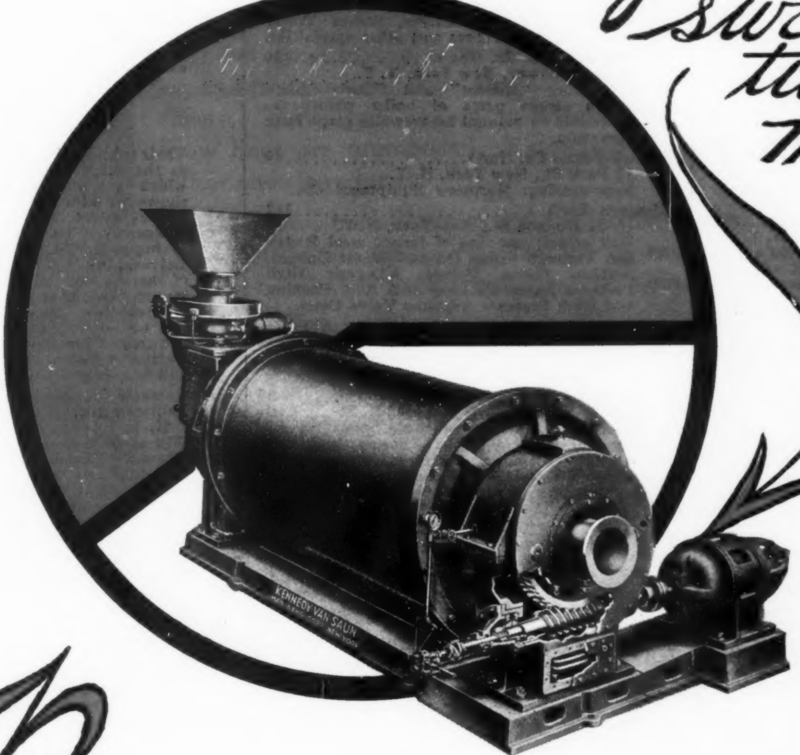
International Nickel Company (Inc.)..........9
67 Wall St., New York, N. Y.
Will exhibit Monel Metal and Pure Nickel in commercial forms such as rods, sheet, tubes, strip, wire, forgings, castings, etc. Special displays will be shown of samples of finished vital parts of power plant equipment as produced by leading manufacturers in this field.

Iron Fireman of New York............291–292
Portland, Oregon
Two Iron Fireman models will be exhibited. One will be a large size industrial bituminous burner. The other exhibit will be the domestic anthracite burner with automatic ash remover.

Continued on page 84

Advertisements of firms listed in color appear on pages indicated

Why will 40 tons out of every 100 tons of fuel pulverized by machinery purchased during May-June-July 1930 be produced by the Kennedy air swept tube mill?



Because—The Kennedy System is the pulverized fuel system with the troubles left out.

You are invited to our booth number 30

Kennedy-Van Saun

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Continued from Page 82 **Booth**

Irving Iron Works Co. 439–440
Dutchkill Creek & 3rd St., Long Island City, N. Y.
Showing Irvico Continuous Open Steel Flooring and Safsteps; Irvico Continuous Armoring for Highways, Bridges and Industrial Floors; Irvico Unified Reinforcement and Armoring Construction for Concrete Slab Floors; and Irvico Unified construction for Precast Concrete Crossing Slabs.

Janette Mfg. Co. 538
556 W. Monroe St., Chicago, Ill.
Manufacturers of Air Compressors, Blowers, Rotary Electric Converters, Pumps, Oil Strainers, Speed Reducing Units, Grinding Machines and Polishing and Buffing Lathes.

Jarecki Manufacturing Company 518–519
Erie, Pennsylvania
Showing Malleable, Cast Iron, and Brass Pipe Fittings, Iron and Brass Valves and Cocks, and a new Heavy Duty High Speed Pipe Threading Machine.

Jay Bee Sales Co. 547
395 Broadway, New York, N. Y.
Manufacturers of Crushing, Pulverizing, and Grinding Machinery.

Johns-Manville (Inc.) 14
292 Madison Ave., New York, N. Y.
Exhibit will feature the complete J-M line of pipe and boiler wall insulations for the entire industrial temperature range from sub-zero conditions to the highest industrial temperatures, refractory cements and packings. In addition, J-M industrial floorings, built-up roofs and other power plant specialities.

Kaye & MacDonald (Inc.) 212
94 Franklin Avenue, West Orange, N. J.
Exhibiting their Safety Steam Trap in operation with the cover removed and will also have a glass model of the K-Master Inverted Bucket Steam Trap in operation.

Keasbey & Mattison Co. ....3 E
Ambler, Pa.
Exhibit this year will be based largely on 85% Magnesia and Ambler High Temperature Pipe Covering. Expect to have an actual installation of Pipe Covering in booth. Will also feature Packings and Gaskets.

Keating, E. F., Pipe Bending Co. (Inc.) ..229–230
Hartford, Conn.
Exhibit will include: Pipe Bend; Welded Headers; and Vanstone joints of Brass, Toncan Iron, Steel, Copper and Genuine Wrought Iron Pipe. Also Coils; Boiler Tubes; Valves; Fittings and pipe.

Keeler, E., Co. 21
Williamsport, Pa.
Exhibiting working glass boiler models, which have proved of much interest to engineers in the past few years, as well as parts of boilers showing the method of construction and design.

Keller Mechanical Engr. Corp'n 645–646
70 Washington St., Brooklyn, N. Y.
Showing in operation, Flexible shaft machines for grinding, filing, polishing. New attachments: 10'-shaft, Automatic Filer, Under Cutter, Slow Speed Drive, Right Angle Polisher, complete line of rotary files, new double shaft machine with low and high speed drives.

Kellogg, M. W., Co. 31
225 Broadway, New York, N. Y.
Will exhibit various of their products manufactured by the forge and hammer lap welded process, as well as various types of flanges, gaskets and joints. Of particular interest will be a section of a forge and hammer lap welded boiler drum.

Kennedy-Van Saun Mfg. & Engrg. Corp'n 30
2 Park Ave., New York, N. Y.
See Adv. Page 83

Exhibition consists of a scene-in-action view, which shows the operation of that company's pulverized coal firing system. This view shows in detail the action of the Kennedy Air-Swept Tube Mill system. They are also showing a scene-in-action of their electric driven gyratory crusher. In addition to the above, interesting photographs and views of their installations are shown.

Keuffel & Esser Co. 612
Hoboken, N. J.
Will exhibit their new line of Hudson & Fulton drawing tables. Also samples of their DUPRO tracing cloth reproductions and NOUPOS prints of tracings in black and white, and a general line of their merchandise.

Keystone Lubricating Company 3
21st, Clearfield and Lippincott St., Philadelphia, Pa.
The products to be shown and main features of exhibit are as follows: Keystone Grease lubricants; and Keystone Safety Lubricating Systems including the Pneuma-Lectric completely automatic system.

Keystone Refractories Company 11
120 Liberty Street, New York, N. Y.
DURA-STIX Firebrick Cement is shown after severe service in a section of furnace wall, demonstrating the thorough bonding qualities of the cement and the actual disappearance of any semblance of joints.

Kidde, Walter & Co. (Inc.) 293
140 Cedar Street, New York, N. Y.
Will show Lux and Fyre-Freez Portable Extinguishers. These extinguishers are of the carbon-dioxide type and are being used extensively to protect electrical, oil, lacquer and other flammable liquid hazards in both Power and Industrial plants.

Kieley & Mueller (Inc.) 281–282
34 W. 13th St., New York, N. Y.
Exhibit will consist of their complete line of Pressure Reducing Valves, Steam Traps, Back Pressure Valves and other specialties.

Kilsoot-Carbocide Co. (Inc.) 449
1834 Broadway, New York, N. Y.
Exhibiting "Kilsoot" and "Carbo-Cide," which cleans parts of boiler plants inaccessible to manual labor while plant is in operation.

Kissick-Fenno Co. (Inc.) 19
15 Park Pl., New York, N. Y.
Representing: Northern Equipment Co.

Klingerit (Inc.) 317
16–22 Hudson St., New York, N. Y.
Will exhibit our line of forged steel Reflex and Through Vision Oil and Water Gauges. Seatless Piston Valves, Klingerit High Pressure Sheet Packing and Rod Packing and High Pressure Asbestos Valve Discs.

Kohlmeier, J. M. (Inc.) 520–521
Long Island City, New York, N. Y.
Representing: Black & Decker Company, and Van Dorn Electric Tool Company.

Korfund Co. (Inc.) ....15 B
235 East 42nd St., New York, N. Y.
Featuring materials for the isolation of machine vibration and the soundproofing of rooms. Korfund: natural cork foundation plates. Vibro-Dampers: an adjustable spring devise for the elimination of machine vibration. Absorbo-Phone: for soundproofing floors. Absorbit: for soundproofing walls.

Kraissl Co. 430
23 East 26th St., New York, N. Y.
Products to be shown will be pumps and strainers of various types, including centrifugal pumps, rotary pumps, fuel oil pumps, internal gear pumps, vacuum pumps, and possibly steam pumps.

LaBour Company 32
Elkhart, Indiana
Will show self priming centrifugal pump in operation and direct connected to several of new type automatic suction control valves.

Ladd Water Tube Boiler Co. 23
Pittsburgh, Pa.
(See Combustion Engineering Corp'n.)

Lead Lined Iron Pipe Co. 11
Wakefield, Mass.
Exhibiting "Wakefield" Amalgamated Acid Resisting Lead Lined Pipe, Fittings and Valves; "Wakefield" Galvanized Amalgamated Lead Lined Pipe, Fittings, and Valves; "Wakefield" Amalgamated Pure Block Tin Lined Pipe, Fittings, and Valves; and "Wakefield" Lead and Tin Coated and Covered Pipe, Fittings.

Leavitt Machine Company 255
Orange, Mass.
Exhibit will include the complete line of Dexter Valve Reseating Machines. The complete line consists of the following machines: Dexter Globe Valve Reseating Machines; Dexter Gate Valve Reseating Machines; Dexter Pump Valve Reseating Machines; and Dexter Tank Car Outlet Valve Reseating Machines.

Leeds & Northrup Co. 18
4901 Stenton Ave., Philadelphia, Pa.
Will exhibit the following equipment: Metered Combustion Control; Automatic Frequency Control; Percent Leakage Recorder (for measuring condenser leakage); Smoke Recorder; Speed Recorder; Meuller Thermometer Bridge; Semi-Precision Potentiometer; Platinum Resistance Thermometers; and Thermocouples.

Leslie Co. 556–557
Lyndhurst, N. J.
Showing pressure regulators and reducing valves pump regulators—constant or excess type. Self contained. No stuffing boxes or drips. All working and wearing parts renewable.

Lewellen Mfg. Co. 615
Columbus, Ind.
Will display a complete line of LEWELLEN variable speed transmissions both vertical and horizontal types.

Limitorque Corp'n 16
17 East 45th St., New York, N. Y.
Exhibiting a Limitorque operated high pressure steam valve that will be shown opening and closing in response to the human voice without the aid of any magnetically operated equipment.

Linde Air Products Co. 334–335
205 East 42nd St., New York, N. Y.
The strength and dependability of power piping and equipment fabricated by oxyacetylene welding will be the theme of the exhibit. Complicated headers and pressure vessel joints fabricated by oxwelding will be displayed. The Oxweld Type W-17 Welding Blowpipe with Cutting Attachment will be exhibited.

Link-Belt Co. 285–287
910 S. Michigan Ave., Chicago, Ill.
See Adv. Pages 116, 117

Their exhibit will be enlarged upon this year, as the P.I.V. Variable Speed Transmission, which has just been announced, will be shown in addition to their line of Positive Drives (Silent Chain, Roller Chain and Speed Reducers). To demonstrate the possible saving in R.P.M. through the use of Positive Drives, Link-Belt will have operating exhibits of these units. A comprehensive exhibit of Power Plant coal handling equipment, such as elevators, conveyors, skip hoists, etc., will be on display through the medium of pictures of installations in the leading generating stations, industrial and commercial building power plants.

Liquidometer Co. (Inc.) 487–488
Skillman Ave. & 37th St., Long Island City, N. Y.
Will show a complete line of "Direct" and "Remote" Reading Tank Contents Gauges, including new Scale gauge for measuring by weight, liquid stored in large tanks and new line of Aircraft gauges.

Lockwood Trade Journal Co. (Inc.) 524
10 East 39th St., New York, N. Y.
Exhibit will display sample copies of their various publications, including Paper Trade Journal and Lockwoods Directory of Paper and Allied Trades.

Mc Avoy Products Co. 525
19 W. Jackson Blvd., Chicago, Ill.
Will have at their exhibit a Water Treatment, new in its discovery, that positively eliminates scale, corrosion, rust, pitting, foaming, etc., and that is drinkable.

McGill Metal Co. 266
Valparaiso, Ind.
Showing Schubert Ball Bearings.

Manistee Iron Works Co. 48
Manistee, Mich.
Exhibit will consist of several Pumping Units. There will be a sectional eight-stage Pump and a four-stage Boiler feeder for High Pressure service. There will be several Single stage Volute Pumps.

Manufacturers Record 40
Baltimore, Md.
The Manufacturers Record each week for 48 years has been interpreting the Business South. In making known the South's resources and its industrial and agricultural development, it has become the recognized authority in all matters relating to the South.

Marburg Bros. (Inc.) 427
90 West St., New York, N. Y.
"Thiel" Precision Die Sawing and Filing Machines will be exhibited.

Marschke Mfg. Co. 520
Towson, Maryland
(See Black & Decker Company.)

Marsh, James P., & Company 258–259
2073 Southport Ave., Chicago, Ill.
Will exhibit the Marsh lines of heating systems, units and industrial instruments. The main feature of the exhibit will be a complete operating display of the Marsh Weather Compensating System of Heating.

Mason Regulator Co. 218
Dorchester Center, Boston, Mass.
This exhibit will include a complete line of

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Ninth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108* Booths No. 401 to 656—Third Floor—*Diagram on Page 110*

Continued from Page 84 **Booth**

Pressure Reducing Valves, Pump Governors, Damper Regulators and Balanced Valves. One of the features will be their No. 329 double diaphragm auxiliary operated reducing pressure valve.

Materials Handling & Distribution..........446
420 Lexington Ave., New York, N. Y.
Will exhibit their publication, Materials Handling & Distribution.

Mechanical Catalog..........................80
29 West 39th St., New York, N. Y.
Published annually by the American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. The only specialized reference work for the buyer and specifier of mechanical equipment and engineering materials. Contains Mechanical Equipment Directory. Copies will be available for inspection.

Mechanical Engineering......................80
29 West 39th St., New York, N. Y.
Published monthly by The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y. The only technical publication in America which covers all branches of mechanical engineering practice. Copies available for inspection.

Mercoid Corp'n........................215–216
564 W. Adams St., Chicago, Ill.
Will exhibit various types of controls as Thermostats, Pressure Controls, Low Water Cut-Off Controls, controls for oil burners, stokers and unit heaters.

Merrick Scale Mfg. Co.................237–240
188 Autumn St., Passaic, N. J.
Will have on exhibit the Merrick Conveyor Weightometer, which is a conveyor scale, weighing coal. The Merrick Addoweight weighing buckets of coal passing along a monorail track. The Merrick Mechanical Weighman for weighing tanks of material, either liquid, pulverized or crushed.

Midwest Piping & Supply Co.........221–222
1440 So. Second St., St. Louis, Mo.
..................*See Adv. Page 104*
Will exhibit various new modifications of Van Stone joints including the Globack and Midwest. Will exhibit also a display of modern welding as well as pulled test specimens of welding and Van Stone joints. Forge and hammer welded flanges will be on display, as will be rough wrought iron and brass Van Stone pieces.

Mill & Factory Illustrated..................446
420 Lexington Ave., New York, N. Y.
Copies of their publications Mill and Factory Illustrated and Materials Handling and Distribution.

Millers Falls Co............................431
Millers Falls, Mass.
Will demonstrate their full line of Portable Electric Tools comprising electric drills in capacities $^3/_{16}$" to $^7/_8$" inclusive and full range of electric screw drivers, electric saws, grinders, polishers and hammers.

Minneapolis-Honeywell Regulator Co....235–236
Minneapolis, Minn.
Showing Electric Motor and Solenoid-operated Valves; Temperature, Pressure, and Combustion Safety Controllers, including auxiliary relays, for the Process Industries.

Mixing Equipment Co. (Inc.)...........279–280
1024 Garson Ave., Rochester, N. Y.
Will exhibit several different models of LIGHTNIN Portable Mixers, Side Angular Propeller Type Agitators, Mixing Tanks, Kettles, etc.

Morse Chain Co.........................267–268
Ithaca, N. Y.
Morse Silent Chain Drives, Flexible Couplings, Structural Steel Speed Reducers, Ring and Disc Oilers and chain parts will be exhibited.

Moto Meter Gauge & Equip. Corp'n.....622–623
11 Wilbur Ave., Long Island City, N. Y.
Will exhibit Motoco Industrial Thermometers; Motoco Recording Thermometers; Pressure and Oxy-Acetylene Gauges; and Etched Products and Moulded Products.

Multi-Valve Corporation....................489
New London, Conn.
Will exhibit the Multi-Stage Valve described in the enclosed literature. Will have a variety of finished size and types, working models with part of body cut away, and complete sets of loose working parts.

Nash Engineering Co......................53–66
South Norwalk, Conn.
Manufacturers of Gas Compressors, Air Compressors, Vacuum Pumps, Condensation Pumps, Centrifugal Pumps, Sewage Ejectors, and Condensation Return Systems.

Booth

Nathan Mfg. Co.......................530–531
250 Park Ave., New York, N. Y.
....................*See Adv. Page 89*
Miscellaneous mechanical lubricators in connection with various types of bearings and other parts to be lubricated shown in actual operation. In all Nathan mechanical lubricators a simultaneously oscillating and reciprocating piston is provided for each feed. No valves are used. Loose pulleys equipped with Nathan Automatic Oil Feeders shown in operation. These feeders serve to lubricate bearing surfaces in minute but sufficient quantities.

National Ass'n of Power Engineers...........95
Chicago, Ill.
Will have an educational exhibit. The Educational Department, the Promotion Department and their official publication (National Engineer) will be represented. Progress In Operation for which the association stands—will be the keynote of the exhibit.

National Company (Inc.).....................76
Malden, Mass.
Will exhibit Water Column Gauge Glass Illuminators, particularly the new "Type L" National Illuminator for flat type gauges; electric compartment cell door hardware.

National Engineer............................95
Witherspoon Bldg., Philadelphia, Pa.

National Regulator Co.....................81–82
2301 N. Knox Ave., Chicago, Ill.
Exhibiting High Pressure Damper Regulators.

National Tube Co.......................535–537
Frick Bldg., Pittsburgh, Pa.
Will exhibit welded and seamless pipe for power piping, boiler tubes and safe ends, physical tests on pipe and boiler tubes, and models showing the method of manufacturing seamless pipe.

Neemes Foundry (Inc.)........................56
206 First St., Troy, N. Y.
Will exhibit full size operating models of the Neemes Automatic Stoker, Neemes Superior Dumping Grate and Neemes Improved Shaking Grate.

New York & Richmond Gas Co...................7
Stapleton, Staten Island, New York, N. Y.
See American Gas Association (Inc.).

Nicholson, W. H., & Co.......................92
138 Oregon St., Wilkes-Barre, Pa.
Exhibiting Piston Operated Steam Trap, Weight Operated Steam Trap, All Metal Flexible Coupling, and Four-Way Valves and Steam Specialties.

Norma-Hoffmann Bearings Corporation..........................263–264
Stamford, Conn.
...................*See Adv. Page 130*
Will exhibit a complete range of sample ball, roller and thrust bearings such as we manufacture. Expect to feature for the first time at the New York Show their new self-aligning and angular contact ball bearings as well as their new "GreaSeal" felt protected bearings. In addition will show several pieces of equipment fitted with their bearings, these units being sectioned to illustrate the bearing mounting.

North Electric Mfg. Co......................417
Galion, Ohio
Will exhibit an Automatic Telephone System for inter-departmental communication, the switching equipment of which is composed of relays exclusively, also Remote Supervisory Power Control apparatus.

Northern Equipment Co..........................19
Erie, Pa.
.....................*See Adv. Page 97*
Will again exhibit the Copes System of Boiler Feed Control. The display will feature a demonstration and explanation of excess pressure control in the boiler feed line. A Copes Feed Water Regulator and a Copes Type SS Differential Water Pressure Regulating Valve are shown installed in the feed line to a typical boiler. The equipment is full size, and cut away so that operation can be readily seen. Meters showing load and water flow and a continuous chart giving pump pressure, regulator inlet pressure and boiler pressure reproduce the action of the equipment under conditions of changing boiler loads. A Copes Valve Movement Indicator shows how the regulator valve opens and closes in accordance with changes in boiler water level. Another feature will be the Copes Type RG Valve which combines the Copes flow control valve

Booth

with the Copes excess pressure control valve in a single compact body. The Copes Type DS Pump Governor will also be shown, as will the Copes Type CRI Valve for high-pressure condensate drainage control.

Norton Company...............................10
Worcester, Mass.
Will exhibit Alundum bricks, Crystolon bricks refractory cements, electrically fused magnesia products, linings for enamelling furnaces, linings for ceramic kilns and steel treating furnaces, tubes, cores and muffles. Will also show Alundum grinding wheels and Crystolon grinding wheels.

Nugent, Wm. W., & Co........................490
410 N. Hermitage Ave., Chicago, Ill.
Products exhibited will be working Models of Gravity and Pressure Types of Oil Filters and Pumps, also: full size Sight Feed Valves; Sight Flow Indicators; Telescopic Oilers; Multiple Oilers; Compression Union Threadless Pipe Fittings; Oil Pumps; Crank Pin Oilers; Oil Level Gauges; and Oil Fittings.

Nye Tool & Machine Works....................641
4120 Fullerton Ave., Chicago, Ill.
Exhibit consists of their Lightweight Champion Pipe Threading and Cutting Machine, having a capacity of from $^1/_2$" to 2", equipped with Universal motor, also Gasoline Engine.

O. D. Patents Corp'n........................462
541 Isham St., New York, N. Y.
Showing the Design-Aidor which embodies several useful time saving devices, which enables the practical engineer and draftsman to gain result in a fraction of time compared with using other tools.

Oakite Products (Inc.)......................257
22 Thames St., New York, N. Y.
Cleaning operations in the several divisions in power plants, such as the cleaning of oil coolers, surface condensers and generators in the engine-room division; transformers, high tension insulators, boiler fronts and lighting equipment in the electrical division; and repair and maintenance in machine shops, will be informatively shown.

Obermayer, S., Company.......................27
2563 West 18th St., Chicago, Illinois
Will exhibit RAMTITE in the new standard package—a one hundred pound waterproof carton, HOTT-PATCH Patented High Temperature Cement, and other refractory specialties. Also sections of a furnace built with RAMTITE and HOTT-PATCH.

Okonite Co..................................619
501 Fifth Ave., New York, N. Y.
Will exhibit Okonite and Varnished Cambric Cables for many uses and Okonite-Callender Impregnated Paper-Insulated Cables for high tension power; also Hazard wires and cables; also a testing machine for comparing tests on rubber sheathed cords.

Okonite Callender Cable Co. (Inc.)..........619
Paterson, N. J.
(See Okonite Company.)

Olsen, Tinius, Testing Machine Co............17
500 N. 12th St., Philadelphia, Pa.
Will exhibit new types of Dynamic Balancing Machines, as well as new types of testing machines. Will demonstrate a new type of Dynamic Balancing Machine. There will also be exhibited a small Olsen-Lundgren Dynamic Type of Balancing Machine, as well as one of the latest Olsen-Lundgren Static Balancing Machines.

Oxweld Acetylene Co.........................334
30 East 42nd St., New York, N. Y.
Manufacturers of Oxyacetylene Welding and Cutting Outfits. Also supplies.

Palmer-Bee Co...............................266
Detroit, Mich.

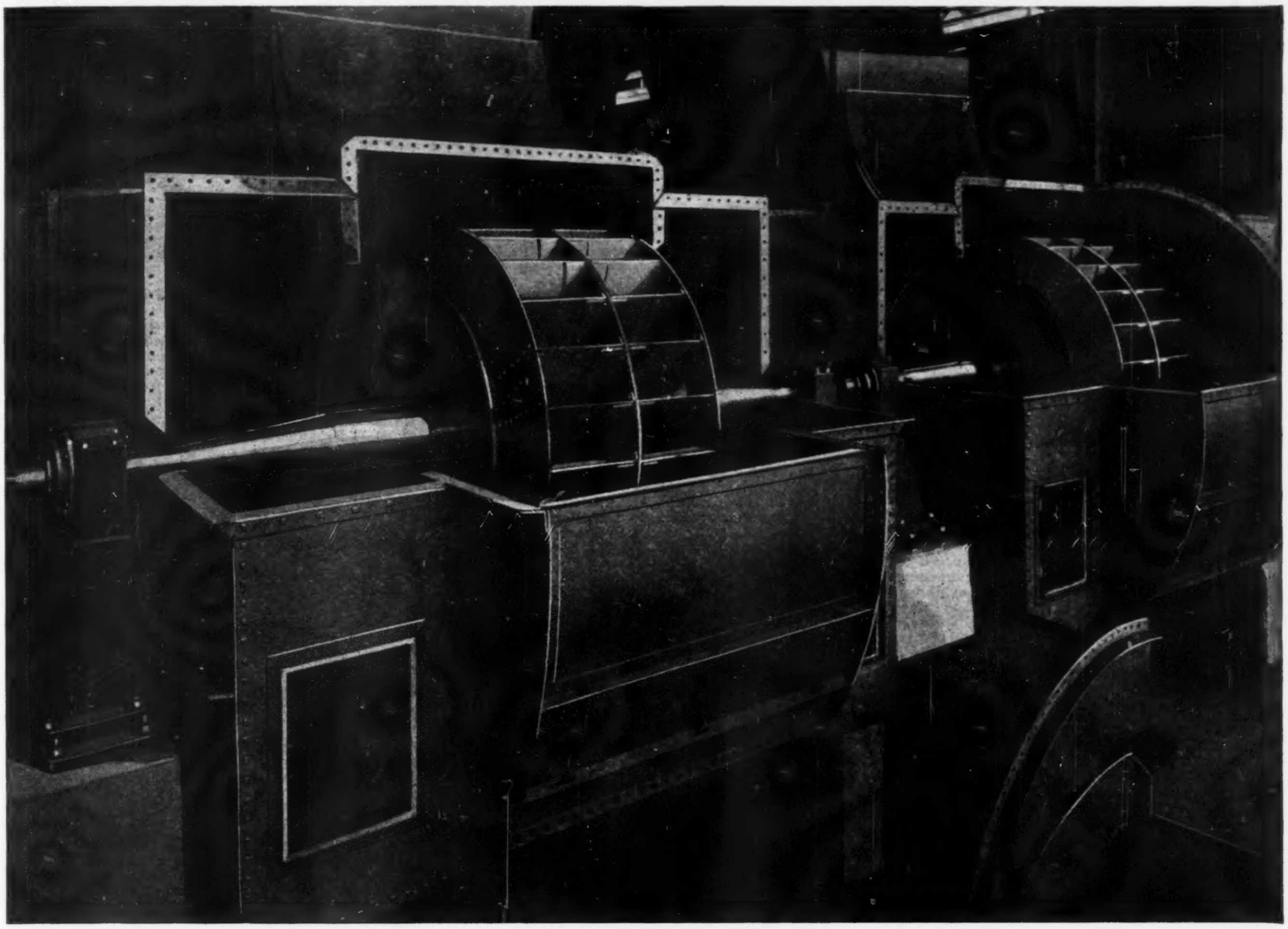
Paper Trade Journal.........................524
10 E. 39th St., New York, N. Y.

Parker Appliance Co.................626–627
10320 Berea Rd., Cleveland, Ohio
.....................*See Adv. Page 79*
Will display Parker Tube Couplings—Standard, Extra Heavy and Triple types. The Triple Type of coupling being introduced this past year. Parker Hand and Production Benders, Valves, Coils, Draft Meter Manifolds and Power Plant Units will also be on display.

Peerless Machine Co..........................529
1218 Sixteenth St., Racine, Wis.
Exhibit will consist of our Peerless Universal Type High Speed Metal Sawing Machines and their Universal No. 2 Portable Pipe Threading & Cutting Machine.

Continued on page 88

Advertisements of firms listed in color appear on pages indicated



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Continued from Page 86 **Booth**

Pels, Henry & Co. (Inc.)......................2
90 West St., New York, N. Y.
Will exhibit one Quadruple Combination Punch, Plate Shear, Bar and Angle Shear with built-in Coper, Type MAE-16, with guaranteed Unbreakable Steel Plate Frame, for performing various punching, shearing and notching operations.

Perkeo Distributing Co. of America.........652
259 Lafayette St., New York, N. Y.
Manufacturers of Automatic Soldering Irons.

Perkins Machine & Gear Company..........266
Springfield, Mass.
Showing an attractive display of unusually fine gears. This class of work is such gears as are found in talking picture machines, electric drills, washing machines, etc., where there is quantity production and very accurate gears are required.

Permutit Co....................306–307, 348
440 Fourth Ave., New York, N. Y.
...................*See Adv. Page 95*
Will have two exhibits, Ranarex CO_2 and Gas Density Recorders will be shown in Booths No. 306 and No. 307; and Water Softening Equipment will be shown in Booth No. 348. All of the Ranarex machines will be shown in operation. The exhibit in Booth No. 348 will include a 30" Permutit Water Softener, a 12" Water Softener; and Electro Chemical Feeds in operation. Both Constant and Intermittent types of feed will be shown. The Permutit Company manufacturers all types of Water Softeners—Zeolite, Hot and Cold Lime Soda, Lime-Barium. Sand Filters. Iron, Oil and Manganese Removing Filters. Continuous Boiler Blowoff Equipment. Ranarex CO_2 Indicators and Recorders. Other Power Plant and Water Treating Specialties.

Pettey & Wherry (Inc.)......................615
50 Church St., New York, N. Y.
Representing Llewellyn Company.

Philadelphia Gear Works......................18
Richmond & Tioga Sts., Philadelphia, Pa.
...................*See Adv. Page 81*
Will exhibit their standard line of Speed Reducing Units, Spiral Bevel Gears, Continuous Tooth Herringbone Gears, and Standard gears of all types.

Pittsburgh Coal Company.............336–337
Pittsburgh, Pa.
Will show several still pictures of their mechanical cleaning plants in which approximately 50,000 tons of coal a day are cleaned, dried, and sized.

Plibrico Jointless Fire Brick Co..............92
1840 Kingsbury St., Chicago, Ill.
Exhibit will show jointless Plibrico Furnace Lining with its use as a refractory lining for boilers and industrial furnaces. The construction of Plibrico air-cooled and Plibrico-backed water walls will be featured.

Porter-Cable-Hutchinson Corp'n........630–631
Syracuse, N. Y.
Exhibiting the following machines: Every-Ready Combination Woodworker, Beaver Woodworker, Take-About Sander, Speedmatic Saw, Belt and Disc Sanders.

Power....................................42
10th Ave. & 36th St., New York, N. Y.
Will have on exhibition copies of the publications, Power, and engineering books published by their subsidiary, McGraw-Hill Book Company.

Power House..............................509
153 University Ave., Toronto, Ontario
Showing Power House, a technical paper which has been published in the interests of the stationery engineers of Canada for the past 22 years.

Power Plant Engineering....................37
53 W. Jackson Blvd., Chicago, Ill.
Booth will contain an exhibit of their publication and sample copies will be available.

Prat-Daniel Corp'n....................26–26A
183 Madison Ave., New York, N. Y.
Will exhibit the following: Thermix Air Preheater for use with power plant boiler to recover the heat from the flue gases for the preheating of air; Thermix Mechanical Draft Stacks; Thermix Dust Collecting Induced Draft Fan.

Preferred Utilities Co. (Inc.)............303–305
33 W. 60th St., New York, N. Y.
In booths 303 and 304 Ray Burners with controls for domestic, commercial, and industrial use will be on display. In booth 305 the Hart domestic oil burner will be on display.

Booth

Pressure Snubber Co......................606
Charlotte, N. C.
Demonstrating a patented restriction for various types of pressure lines, having a traveling clearing pin which prevents sediment entering the recording gauge, absorbs all shock equalizing pressure.

Production Machine Co....................460
Greenfield, Mass.
Will exhibit both types "A" and "S" Centerless Polishing and Finishing Machines and type "D" patent cushion wheel belt polishing machine.

Quimby Pump Co. (Inc.)............252–253
393 Seventh Avenue, New York, N. Y.
...................*See Adv. Page 127*
Will exhibit the following pumps: Quimby Fuel Oil Pump in operation; Quimby Screw Pump for water; Rubber-lined centrifugal pump; Non-corroding centrifugal pump; 8 stage high pressure centrifugal pump; Small sump pump; Air operated Pneumatic Sump Pump; and Paper Stock pump in operation. Of these the rubber lined pump, paper stock pump and air operated sump pump.

Radiator Specialty Co.....................606
Charlotte, N. C.
Will exhibit boiler solder seal, a repair for leaking steam and hot water heating systems, and W J boiler and heating system cleanser.

Rawlplug Co. (Inc.)......................539
66. W. Broadway, New York, N. Y.
Showing rawlplugs. Screw anchor expansion shields made of jute, vibration resisting, hole and anchor no larger than diameter of screw.

Ray Burner Co............................303
170 Sutter Ave., San Francisco, Cal.
Manufacturers of Rotary Oil Burners.

Reeves Pulley Co. of New York (Inc.).....34–35
76 Dey St., New York, N. Y.
Exhibiting very latest design of Reeves variable speed transmissions, all units in operation.

Refractory & Engineering Corp'n............74
50 Church St., New York, N. Y.
Exhibiting High Temperature Cements and Insulations. Exhibit will present their products in such a manner as to show their actual application, by small models on which their cements may be applied illustrating their use in actual practice.

Reliance Elect. & Engrg. Co...........542–543
1084 Ivanhoe Rd., Cleveland, Ohio
Products to be shown—alternating-current motors which can be supplied in sizes up to 150 hp. and direct-current in sizes up to 250 hp. Open, fully-enclosed, and fan-cooled motors of both types will be shown.

Reliance Gauge Column Co..............81–82
Cleveland, Ohio
Will have on exhibition the working mechanism of Reliance Safety Water Columns, Reliance Tiltview Water Gauge, Reliance Gauge Cocks, also electric alarms, or various pressures up to 750 lbs.

Republic Flow Meters Co.....................6
2240 Diversey Parkway, Chicago, Ill.
...................*See Adv. Pages 72, 73*
The Republic exhibit will feature a complete line of power plant and industrial instruments including flow meters, CO_2 meters, draft instruments, liquid level gauges, pressure gauges, pyrometers and control pyrometers. Special working models of flow meters, CO_2 meters and control pyrometers will be in operation, featuring the latest developments in these types of instruments. The exhibit will also include a display of large steel boiler panels and master panels, featuring various combinations of flush mounted reading instruments as well as a display of individual reading instruments.

Rhoads, J. E., & Sons.................567–568
35 North Sixth St., Philadelphia, Pa.
Will exhibit Rhoads Tannate Watershed and oak-leather Beltings; Tannate straps, washers, packings; Tannate Lace Leather and Belt Preservers. Will also show, in operation, two belt testing machines illustrating short center, high Pulley ratio drives equipped with Rhoads Tannate flat belts.

Riley Stoker Corp'n....................78–89
Worcester, Mass.
Will exhibit an improved Riley Atrita Unit Pulverizer. Will also exhibit a Riley Flare Type Burner and a newly developed burner known as the Riley Cyclone Burner. Will also exhibit a complete Jones Side Dump Stoker having moving combustion grates and the latest type of Riflex Mechanical Drive.

Booth

Robinson, John R..........................613
110 West 34th St., New York, N. Y.
Exhibiting Gaskets, Steelbestos. Also the Triple-Blade Tube-Hole Cleaner and a few other articles used in the boiler room of steam and electric plants.

Roller Bearing Company of America..........564
Trenton, New Jersey
A most unusual display, using a table constructed of the rollers as used in our bearing and will show various types of bearings that we manufacture in sizes from 7/16" shaft up to 13", with pieces taken from the various stages of manufacture.

Roller-Smith Company......................256
233 Broadway, New York, N. Y.
Will exhibit a comprehensive line of AC and DC electrical measuring instruments, both indicating and recording, including switchboard and portable type ammeters, milliammeters, voltmeters, milli-voltmeters, voltammeters, wattmeters, frequency meters, power factor meters, reactive factor meters, ohmmeters, bond testers and circuit testers. In addition there will be many types of relays. Also will show air circuit breakers, AC and DC, and high voltage oil switches and breakers for AC.

Rollway Bearings Co. Inc.)... ....2N
Syracuse, N. Y.
....*See Adv. Page 129*
The main feature of their exhibit will be a full size working section of a bridge truck wheel assembly of a large industrial crane. The bearing housing and part of the bearing will be cut away to show the Rollway floating type bearing in action. In addition to this truck wheel assembly, will also have on exhibition the majority of the types of precision radial bearings that they manufacture along with the various types of roller thrust bearings that are used in industry.

Rome Brass Radiator Corporation.......482–484
1 E. 42nd St., New York, N. Y.
Exhibit will show a typical installation of the new Robras Box Fin Radiator together with various samples. Will also show the Aulbras Indirect Heater in several sizes.

Rotor Air Tool Company....................653
5704 Carnegie Ave., Cleveland, Ohio
Will have an operating exhibit with a complete line of Portable Pneumatic Tools consisting of Grinders, Sanders, Buffers and Drills, with the addition of new drills for nut setting, and screw driving, and tools for finishing stone and concrete.

Rowan Controller Co........................3N
306 N. Holliday St., Baltimore, Md.
Will have on display one unit of practically every line which they manufacture. Visitors interested in Rowan Oil Immersed Control will of course be supplied with literature describing the types of equipment in which they are particularly interested.

Ryerson, J. T., & Sons (Inc.)...........432–433
P. O. Box 484, Jersey City, N. J.
Booth 433 will be an exhibit of various iron and steel commodities, such as structural steel, Cold Rolled steel, Allegheny Metal, tool steel, babbitt metal, sheet steel, mechanically burned heavy steel plates and Lewis Special Iron. Booth 432 will be the Ryerson Machinery exhibit, wherein will be displayed a Ryerson combination shear, punch and coping machine, and a Wilson "Plastic-Arc" Welder.

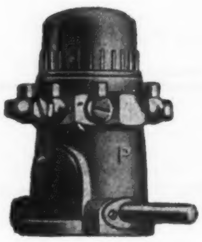
S K F Industries (Inc.)................223–224
40 East 34th St., New York, N. Y.
Once again, interesting devices featuring the anti-friction qualities of S K F Bearings will be the center of attraction at the S K F Industries, Inc., exhibit. In addition, there will be on display a complete range of S K F Transmission Appliances.

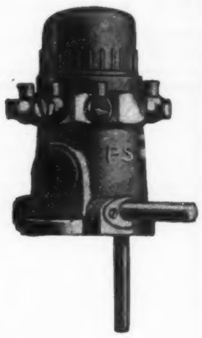
Sarco Co. (Inc.)...........................33
183 Madison Ave., New York, N. Y.
The latest types of Sarco thermostatic Steam Traps, Combination Thermostatic and Float Traps, Sarco Temperature Regulators and Sarco Strainers will be shown. In addition, there will be specimens of the various Sarco Heating System specialties.

Sauerman Bros. (Inc.).....................438
438 S. Clinton St., Chicago, Ill.
The central feature of their exhibit will be a working model of a Sauerman drag scraper system storing and reclaiming coal on a ground storage area adjoining a power plant.

Continued on page 90

Advertisements of firms listed in color appear on pages indicated





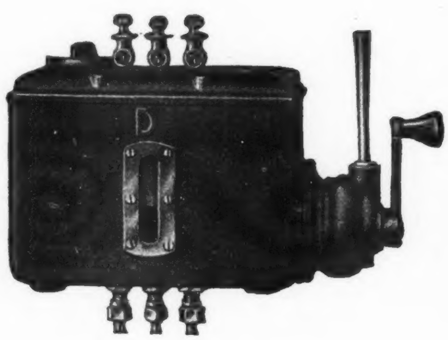
NATHAN

MECHANICAL LUBRICATORS—*now*

built for every industrial use

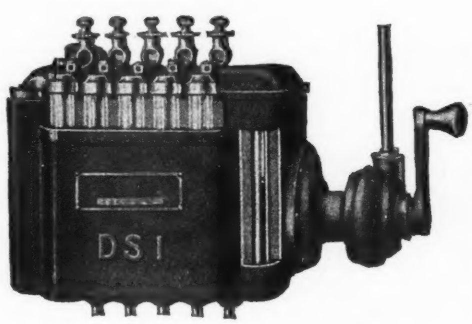
Booths No. 530-531

FOR years, Nathan has been the leader in the production of locomotive mechanical lubricators. Using the same principles of operation, proved so successful in this hard service, Nathan now offers a series of equally dependable mechanical lubricators for use on industrial equipment.

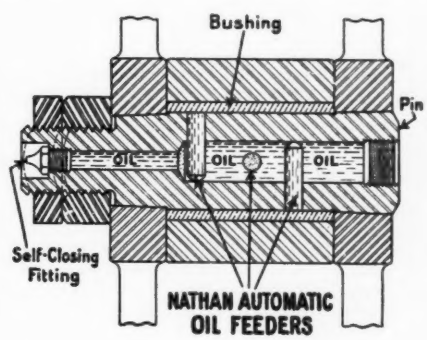


Nathan Mechanical Lubricators provide reliable pressure feed with accurately measured regulation of oil. Pistons and valves are of patented construction. Fewer operating parts are required, reducing wear and resulting in exceptionally low maintenance. There is a size and type particularly adapted to provide the right quantity of lubricant and required number of feeds for every industrial purpose.

Have a Nathan engineer analyze your lubricating requirements. He'll gladly show you why Nathan Mechanical Lubricators assure reliable, accurate and efficient service.



AUTOMATIC OIL FEEDERS—another new Nathan product—a simplified yet effective automatic system of lubricating moving parts with oil. Oil reservoirs are built into parts equipped with this system. Through holes fitted with oil feeders of specially treated wood of unusual characteristics, the correct amount of lubricant filters through to the surfaces to be lubricated. Ask us for complete details.



NATHAN MANUFACTURING COMPANY

250 PARK AVENUE

NEW YORK

Ninth National Exposition of Power and Mechanical Engineering
DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108* Booths No. 401 to 656—Third Floor—*Diagram on Page 110*

Continued from Page 88 **Booth**

Savage, W. J., Co. 654
Knoxville, Tenn.
Will exhibit one No. 136 Nibbler Type Gray Metal Cutter. This machine is the very latest thing in sheet metal cutters. The capacities range from the thinnest sheet up to 1/4" in soft steel. The throat depth ranges from 8" to 36".

Schade Valve Mfg. Co. 76
2527 N. Bodine St., Philadelphia, Pa.
Will exhibit steam, water, air, and oil specialties; pressure reducing valves, regulators, altitude valves, relief valves, and pressure controls.

Schutte & Koerting Co. 342–343
1166 Thompson St., Philadelphia, Pa.
....................*See Adv. Page 75*
Exhibit includes following: Mechanical auxiliaries for steam power plants and for industrial processes; Simplex and Duplex strainers for oil; Spur gear and Herringbone gear pumps for fuel and lubricating oils; these pumps in operation; double tube injector for boilers; section oil cooler; Mixing Eductor for treating processes in oil refineries and chemical plants; one or more valves built for steam power station operating at 1800 lbs. pressure and Continuous heater (steam jet type) for water and other liquids. Also showing sectional pictures of S&K Venturi Reducing valves, hydraulic cylinder operated and electrically operated, the latter to be shown in conjunction with the S&K type "F" electric controller for motor driven reducing valves. This controller will be in operation and its action clearly shown. Also pictures illustrating S&K multi jet condenser for engines and turbines and the S&K spray type desuperheater. A complete line of catalogs covering S&K products will be available. Also showing Radiafin tubes for heating and cooling units. An oil cooler of this type will be attached to one of the gear pumps.

Schwenk Safety Device Co. 467
70 East 45th St., New York, N. Y.
Will exhibit safety handling equipment for barrels drums and carboys. One man can safely handle barrels and drums weighing up to 950 pounds, placing them in position for drainage, rotate, truck and otherwise handle the drum. Schwenk carboy tilters makes the pouring of acids safe.

Scovill Mfg. Co. 69
Waterbury, Conn.
Exhibiting Cup-Drawn condenser tubing and expect to show two methods of installing Scovill condenser tubing.

Scully-Jones & Co. 266
Chicago, Ill.
Exhibiting a line of "Wear Ever" production tools, such as adjustable and solid spacing collars, tap chuck holders, drill sleeves, counter boards, etc.

Sharples Specialty Co. 60
23rd & Westmoreland Sts., Philadelphia, Pa.
The latest developments in combination units will be shown, featuring the Super Centrifuge-filter press. The newly developed horizontal will also be exhibited as well as the well known Pressurtite model.

Shepard Niles Crane & Hoist Corp'n 230–231
Montour Falls, New York
Showing Shepard close clearance compact hoist equipped with their new design Model 21 motor driven trolley; also their Form 1 parallel type compact hoist, both of these machines being shown in operation.

Signal Engineering & Mfg. Co. 415–416
154 W. 14th St., New York, N. Y.
The exhibit consists of Magnetic Relays for all applications requiring less than 20 ampere-contact capacity; electrically operated audible signals of all types; a complete SIGNAL CALL code calling system, specially suitable for industrial plants, and complete interior FIRE ALARM SYSTEM.

Silent Hoist Winch & Crane Co. 548–549
762 Henry St., Brooklyn, N. Y.
Will exhibit Silent Hoist Motor Truck and Tractor Power Winches, Cranes and Derricks; Hand and Electric Telescopic Ash Hoists; Electric and Gasoline Capstans, Winches, Hoists, Car Pullers, Barge Movers, Ship and Dock Winches; Worm Gear Speed Reducers.

Simplex Valve & Meter Co. 76
6753 Upland St., Philadelphia, Pa.
....................*See Adv. Page 112*
Will exhibit Simplex Boiler Feed and Condensate Meters of the Indicating, Recording and Totalizing Type for use with Simplex Venturi Tubes.

Smidth, F. L., & Co. 318
225 Broadway, New York, N. Y.
....................*See Adv. Page 91*
The Lenix Short Center Belt Drive will be exhibited. Special attention will be given to the silent operation of a fine piece of machinery. The short pulley centers not only possibly, but preferably, with the Lenix, will be featured. High belt speed with safety, automatic adjustment of belt tension to meet varying loads will also be demonstrated.

Smith, David H., & Son 648–649, 522–523
5111 Second Avenue, Brooklyn, N. Y.
Angle Bending Roll for Bending Cold Angles, Beams, Channels, Flat and Round Bars. Will also exhibit two different sizes of the SMITH Steel Plate Combination Punch, Plate Shear, Bar Angle, Tee Cutter and Notching Machine. Also representing Black & Decker Company, and Van Dorn Electric Tool Company.

Smith-Monroe Co. 273
South Bend, Ind.
Exhibit will consist of Gast Compressed Air Separators in the following sizes: 3/8", 3/4" and 2", and 3/4" and 2" Gast Compressed Air Aftercoolers. The operation of the Gast Compressed Air Separator will be shown by a Scene-In-Action demonstrator.

Smith & Serrell 85–86
28 Washington Place, Newark, N. J.
....................*See Adv. Page 94*
In addition to showing entire couplings and sectional models of FRANCKE couplings that are now protecting more than 85,000 drives from misalignment troubles, load shocks and vibrations, will have several typical installations where FRANCKE couplings are used.

Smyder, Fred 652
56-13—59th Place, Maspeth, N. Y.
Exhibiting the New Universal Clamp, Veneer Presses, Cabinet Bencher, Smoothing, Rough and Scrub Planes, etc.

Snap-On Tools, Inc. 453
Kenosha, Wisc.
Exhibit will include the complete lines of Snap-On Socket Wrenches and Blue-Point Tools for assembly and maintenance of machinery of all kinds. Wrenches for hand production, as well as wrench sockets and shanks for use on electric and pneumatic motors will be shown.

South Bend Lathe Works 401
426 E. Madison St., South Bend, Ind.
Exhibiting Back Geared Screw Cutting Precision Lathes for the tool room and maintenance department. Will show two Junior Model Motor Driven Lathes operating from light sockets, and one 16" swing by 6' bed Tool Room Lathe.

Southern Power Journal 10
Grant Bldg., Atlanta, Ga.

Sowdon, W. K., & Co. (Inc.) 76
342 Madison Ave., New York, N. Y.
Representing: Ernst Water Column & Gage Company, National Company, Inc., and Schade Valve Mfg. Company.

Spencer Turbine Co. 516–517
Hartford, Conn.
Will have on display Vacuum Producer for Central Cleaning System used for cleaning Factories and Power Plants and removing dust to prevent explosion and remove excess material during the process of manufacture. In addition a Turbo Compressor made of KA2 Nirosta stainless steel used for handling acid fumes and corrosive gases.

Springfield Facing Co. 27
351 Jeffersy St., Newark, N. J.
(See S. Obermayer Company.)

Square D Co. 442–443
6600 Rivard St., Detroit, Mich.
Will show samples of safety switches, disconnects of all kinds, meter switches, lighting panels, power panels, also automatic starters, for A. C. and D. C. current, pressure switches, contactors, etc.

Standard Motor Construction Co. 601
172 Whiton St., Jersey City, N. J.
Exhibit consists of AE-4 type 6" bore by 8" stroke 60 horse power Standard full diesel engine, mounted on a common sub-base with a generator, making a complete Diesel Generator Set of 35 K. W.

Standard Oil Co. of N. Y. 207–209
230 Park Ave., New York, N. Y.
Will consist of an attractive display of the uses of Petroleum Products in the Industry. Industrial Lubricants, Fuel Oil, Automotive Oil and related products will be featured.

Stanley Electric Tool Co. (Inc.) 457–458
New Britain, Conn.
....................*See Adv. Page 128*
Manufacturers of a long line of portable electric tools. Will have an attractive exhibit which will be of particular interest as several new and unique tools, made only by this company, will be demonstrated. The following electric tools can be seen at this exhibit: Drills, Grinders, Hammers, Safety Saws, Stone Saws, Stanley Unishears, and Screw Drivers.

Star Expansion Bolt Co. 202
147 Cedar St., New York, N. Y.
Will exhibit a complete line of expansion shields, including the now popular Dryvins, Tampins, Loxin and Scruin Shields; also Springin Toggle Bolts, along with various types of Star Drills and Hamrtwist Drill Points.

Starrett, L. S., Co. 456
Athol, Mass.
They are celebrating their 50th anniversary in the manufacture of high grade machinist tools and instruments. Will exhibit a representative line of these tools in addition to their high speed and tungsten hacksaw blades, steel tapes, and leveling instruments which are known for their fine quality, accuracy and workmanship.

Staynew Filter Corp'n 419–420
99 N. Water St., Rochester, N. Y.
Will exhibit the "Protectomotor." They are able to supply equipment from the smallest to the largest requirements for cleaning air at atmospheric pressure as well as for removing water, oil, iron rust, pipe scales, etc., from compressed air.

Sterling Engine Co. 64
1252 Niagara St., Buffalo, N. Y.
The Viking model, 6 cylinder, 425 H. P., 8" bore, 9" stroke, 1200 revolutions engine is being exhibited. The Sterling Dolphin 6 cylinder engine, 5 3/4" bore, 6" stroke, with a rating of 180 H. P. at 1200 r.p.m., and 225 H. P. at 1550 r.p.m., is being shown along with the smaller Sterling Petrel engine.

Stockham Pipe & Fittings Co. 485–486
Birmingham, Ala.
The features of the Stockham display will be the Stockham Return Bend, developed primarily for use in oil refinery tube cracking stills. The very latest designs and weights of return bends will be shown, and also samples of the Stockham Lines of cast iron, heavy malleable fittings and steel fittings made in the Stockham Electric Furnace.

Sumet Corporation 507
1543 Fillmore Ave., Buffalo, N. Y.
Exhibiting Actenized Sumet Bronze. A unique demonstration will be shown with five bronze bearings in actual operation.

Sundh Electric Co. (Inc.) 435–436
Parkhurst St. at Ave. C, Newark, N. J.
Their product consists of electrical control devices built for the especial solution of problems. Photographs, and pictures, and other data, will be available.

Superheater Co. 57
60 East 42nd St., New York, N. Y.
A model to scale will be on exhibition of one of two 1400-lb. semi-vertical boilers with Elesco superheaters now being installed at Ford Motor Company. Enlarged sectional layouts of this and other Elesco intertube and interdeck superheaters will also be displayed, as well as a sectional drawing of Elesco desuperheater.

Swartwout Co. 75
18511 Euclid Ave., Cleveland, Ohio
Exhibiting an extensive line of power plant equipment. Included in the exhibit also are pump governors, master controls, desuperheaters, steam separators, exhaust heads, steam traps of all types and feed water heaters as well as Swartwout Rotary Ball Bearing Roof Ventilators.

Syntron Company 638
400 N. Lexington Ave., Pittsburgh, Pa.
Will exhibit SYNTRON Motorless electric Hammers, SYNTRON Portable Saws and electric drills.

Tagliabue, C. J., Mfg. Co. 59
Park & Nordstrom Ave., Brooklyn, N. Y
Among the new and improved instruments to be exhibited will be found a complete line of both Tag Recording and Controlling instruments.

Continued on page 92

Advertisements of firms listed in color appear on pages indicated

Ninth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

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Continued from Page 90 **Booth**

Taylor Instrument Companies..........323–324
Rochester, N. Y.
Will exhibit a full line of temperature and pressure instruments for the Power Plant. Special emphasis will be given to the new Tycos Flush-Mounted Instruments.

Templeton, Kenly & Co....................290
1020 S. Central Ave., Chicago, Ill.
Exhibiting Simplex Jacks.

Templeton Steam Trap Co. (Inc.)...........272
77 Cortlandt St., New York, N. Y.
Templeton Boiler Feed and Pumping Traps will be shown in a working hook-up, demonstrating how condensate is handled and returned direct to the boiler under pressure.

Texas Co...........................514–515
135 East 42nd St., New York, N. Y.
Exhibit will consist of a display of Texaco Petroleum Products, consisting of Industrial Oils, Greases and Motor Oils. Will also have a small gear display featuring our Texaco Crater Compound as a gear lubricant, demulsibility testing machine to show separation qualities of our Turbine Oils together with other general displays.

Thomas Grate Bar Company................251
Birmingham, Ala.
Complete Working Models, as well as a few full size castings will be shown of the Thomas WSD (Wiggling-Shaking-Dumping) Grate Equipment which is suitable for burning coal, both Bituminous and Anthracite, of all size and grades, also Coke, Wood Refuse, or mixtures of these fuels.

Tide Water Oil Sales Corp'n..............15 A
11 Broadway, New York, N. Y.
Will exhibit a complete line of Industrial Lubricating Oils and Greases, as well as Veedol Motor Oils. Will especially feature their new Tycol Turbine and Tycol Diesel Lubricating Oils.

Time-O-Stat Controls Co...............300–302
Elkhart, Ind.
Exhibit will consist of a complete line of automatic controls for oil, gas and coal fired equipment consisting of room thermostats, primary sequence controls, gas valves, safety pilots, limiting devices, controls for gas burning ovens and damper motors.

Timken Roller Bearing Company........332–333
Canton, Ohio
The feature of the exhibit will be a display designed to show the capacity of the bearings for carrying thrust loads, as well as the reduction they effect in friction. The rest of the exhibit will consist of an assortment of bearings of different sizes.

Toledo Pipe Threading Mach. Co........444–445
1425 Summit St., Toledo, Ohio
Exhibit will be their complete line of Pipe Threading and Cutting Tools from 1/8" to 12", also small Portable Pipe Machines, Power Drives, Work Benches and Vises.

Topping Brothers.............288–290, 520–523
159 Varick St., New York, N. Y.
Representing: Black & Decker Company, and Van Dorn Electric Tool Company.

Torchweld Equipment Co..................289
224 N. Carpenter St., Chicago, Ill.
Will show a complete line of gas welding and cutting equipment. Will also demonstrate the new gasoline and oxygen cutting torch which will save every user many dollars daily in their metal cutting costs.

Triplex Machine Tool Co...............402–403
50 Church St., New York, N. Y.
Will exhibit a new type and size of Swiss Jig Boring Machine which has not heretofore been shown.

Troy Engine & Machine Company.........15-B
Troy, Pa.
Will exhibit a Troy Type SH vertical enclosed self-oiling steam engine which will have glass plates so arranged that the working parts can be easily observed.

Trumbull Elect. Mfg. Co..............608–609
Plainville, Conn.
Will show a main display board consisting of three separate panels. The main items of interest that will be mounted on these display boards are Magnetic and Manually Operated Motor Starting Switches in both steel boxes and in cast iron boxes which are used for weather proof installations. Also industrial switches.

Uehling Instrument Co.....................217
473 Getty Ave., Paterson, N. J.
Will exhibit the new Self-Contact Recording and Indicating Potentiometer Pyrometer, The Electrically Operated Apex CO_2 equipment, the Uehling Combined Barometer and Vacuum Recorder, the Uehling Vacuum Recorder, the Uehling Draft Recorder and the Uehling Light Pressure Recorder.

United States Elect. Tool Co...........408–410
Cincinnati, Ohio
Display will consist of an unusually large line of portable electric drills, grinders, and stand grinders. Will feature a power exhibit of drills heretofore unseen.

Universal Metals Bearing Corp'n............288
Rochester, N. Y.
This company, sole producer of Bearium metal, will demonstrate in an effective manner the non-scoring, non-seizing and long life properties of this bearing metal. The metal is supplied in all forms.

Van Dorn Electric Tool Co..................632
Towson, Md.
Will have an operating exhibit of various tools and will feature a display of the complete line of Van Dorn Portable Electric Tools including: Electric Drills; Drill Press Stands; Grinders, Bench and Portable Sanders; Portable Electric Saws; Portable Electric Hammers; Portable Electric Screw Drivers and Nut Reamers; Heavy Duty Grinder and Buffer lines; and High Cycle line of Super Power Production Tools.

Veeder-Root (Inc.)....................324–325
Hartford, Conn.
Will exhibit a complete line of general mechanical and electrical counters for use in all industrial institutions. Will also show a line of fine die castings, and their new predetermining Root type counter.

Vogt, Henry, Machine Company...269–270
Louisville, Kentucky
.............*See Adv. Pages 124, 125*
Exhibiting their regular line of Drop Forged Steel Valves and Fittings for high pressures and temperature service.

Vulcan Soot Cleaner Company..............204
Du Bois, Pa.
Will exhibit their Ratchet and Vulcan Valve Operating Heads. These heads will be mounted on a section of boiler wall, and will be shown in continuous operation. In addition, will also exhibit various parts of soot cleaner apparatus, such as sections of elements, bearings, etc.

Wailes Dove-Hermiston Corp'n.............260
17 Battery Place, New York, N. Y.
Will exhibit protective coatings for the prevention of corrosion of metals. Will also exhibit samples of bituminous materials and illustrations of their use and where they may be applicable.

Wallace, J. D., & Co......................647
156 S. California Ave., Chicago, Ill.
Will exhibit Workace No. 419 Shop Woodworker, Workace No. 14 Band Saw, Workace No. 24 Jig Saw, Workace No. 1 Radial Saw, Workace No. 22 Kut'n-Jigger, and Workace No. 18 Shaper.

Walworth Company.........................90
Statler Building, Boston, Mass.
Will feature the new Walco Pipe Wrench, using motion pictures and actual demonstrations of the wrench in use. The complete line of tools and also C. N. I. (Chrome-Nickel-Iron) Pipe will be included.

Ward Leonard Electric Co.............512–513
Mt. Vernon, N. Y.
Products to be shown will include: Vitrohm (vitreous enameled) resistors; Vitrohm (vitreous enameled) rheostats for all purposes such as field rheostats, motor and generator controllers, battery charging rheostats, etc. Ribohm (heavy duty) rheostats for all purposes; Ribohm (heavy duty) resistors; Magnetic relays; Motor starters and controllers; Vitrohm dimmers for lighting control; and sound control equipment, including faders, attenuation pads, and volume controls.

Watson-Flagg Engineering Co..............656
120 Liberty St., New York, N. Y.

Watts Regulator Company...................39
254 Lowell St., Lawrence, Mass.
Will exhibit the new Watts Boiler Feeder, and also the Watts "U" Tube Heat Interchanger, Damper Regulator, and Pressure Reducing Valves, together with their complete line of Relief Valves.

Webber, F. M., Co........................211
Graybar Bldg., New York, N. Y.
Representing: Hartzell Propeller Company and Wolverine Tube Company.

Weber Insulations (Inc.)..................614
E. Chicago, Ind.

Webster, Warren & Company..........225–226
Camden, New Jersey
Exhibit this year will illustrate equipment used with the Webster MODERATOR, IMPROVED Vacuum and IMPROVED Type "R" Systems of Steam Heating. New devices used with the systems will be the Webster HYLO Vacuum Variator, the Webster Boiler Protector and the Webster Three-Point Supply Valve.

Westinghouse Elect. & Mfg. Co..............68
East Pittsburgh, Pa.
Will exhibit an animated quarter-scale section of Link-Grate Multiple Retort Stoker as applied to boilers for large public utility and industrial steam generating plants; also a motion picture film of a new ash sluicing system which by manual or automatic operation quickly moves the ash to any desired point without the use of ash handling pumps.

Weston Electrical Inst. Copr'n..............234
614 Frelinghuysen Ave., Newark, N. J.
Exhibit will consist of a representative showing of both portable and switchboard Alternating and Direct Current electrical instruments of the indicating type.

Whitney Metal Tool Company..........454–455
110 Forbes Street, Rockford, Illinois
A complete line of their tools will be displayed as well as two new tools—an entirely new method of joining two pieces of metal together and also one of their hand Punches.

Wilson Welder & Metals Co................433
Hoboken Factory Terminal, Hoboken, N. J.
Showing the Wilson "Plastic-Arc" Welder which will be the 200 ampere size. It will be wired up for operation and an expert welding operator will give demonstrations of unusual welding.

Wing, L. J., Mfg. Co.......................61
158 W. 14th St., New York, N. Y.
Will exhibit the following products: Turbine Blower, for forced draft,—for stokered and hand-fired boilers; Steam turbine, capacity up to 50 hp. for driving pumps, fans, etc.; Centrifugal turbine blower, for blowing gas producers, etc.; Compressed Air driven Turbine Blower for mine ventilation; Motor driven forced draft Blower for low pressure boilers; Wing Featherweight Unit Heater.

Wolverine Tube Co........................211
Graybar Building, New York, N. Y.
Exhibiting Wolverine Unit Heaters.

Woodworking Machinery Co.................637
250 No. 11th St., Philadelphia, Pa.
Will exhibit a complete line of Ball Bearing Woodworking Machinery.

Wright-Austin Co..........................28
315 W. Woodbridge St., Detroit, Mich.
Featuring High Pressure Forged Steel Steam Traps, and High Pressure Forged Steel Water Columns, Steam Separators, Oil Separators, Water Columns (Alarm Type), Water Gauges, Try-Cocks, Exhaust Heads, Strainers.

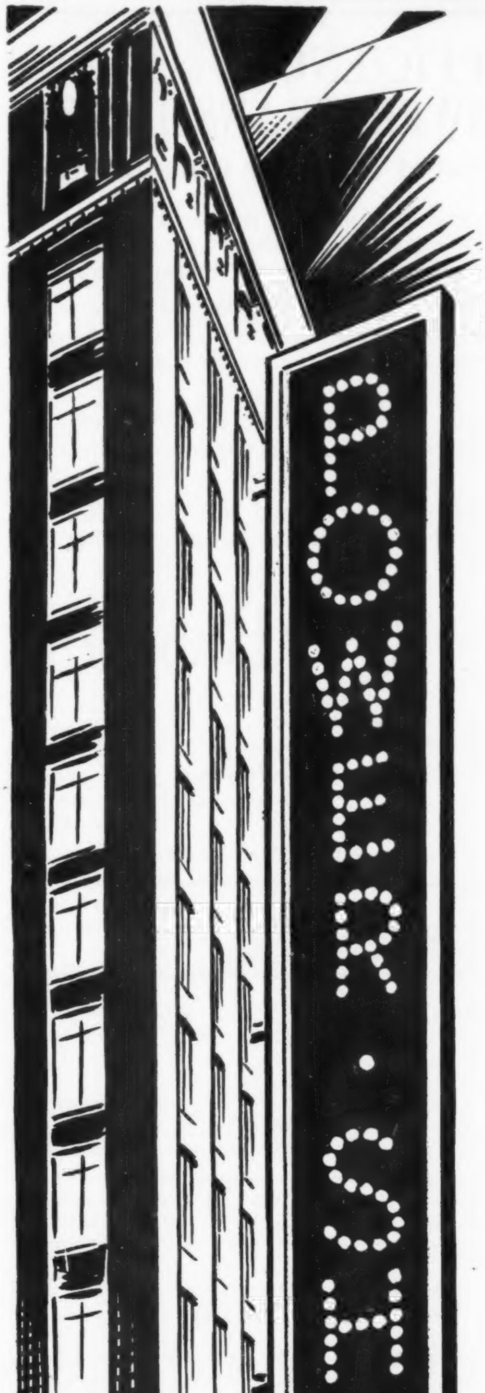
Wright Mfg. Co......................346–347
Bridgeport, Conn.
Exhibit will show Wright Hoists. A movable display will show a new display stand we are bringing out, on which to display Wright Hoists in any show room.

Yale & Towne Mfg. Co...............425–426
Stamford, Conn.
Exhibit will include Yale Electric Industrial Trucks, Tractors, and Trailers, complete overhead material-handling equipment, including Yale Chain Blocks and Trolleys, both hand and electric, and cranes.

Yarnall-Waring Co.........................52
Chestnut Hill, Philadelphia, Pa.
Will exhibit a full line of Yarway Tandem Blow-off Valves for all working pressures up to 2000 lbs., including sectioned samples. Various types of Yarway Floatless Hi-Lo Alarm Water Columns and Yarway Sesure Inclined Gages. A Yarway Cylinder Guided Expansion Joint Yarway Hydraulic Valves of single and two pressure types.

York Heating & Ventilating Corp'n.........14A
1541 Sansom St., Philadelphia, Pa.
See Carrier Corp'n

Youngstown Sheet & Tube Co..........275–276
Youngstown, Ohio
Will exhibit Youngstown electric welded pipe, as well as Youngstown seamless and standard wrought steel pipe; colored illuminated pictures, showing many of the processes in the manufacture of steel; also a complete working model of a pipe mill actually producing small pipe.



Booths 565 & 566

Visitors Welcome

particularly those who are seeking information on

EXPANSION JOINTS

for steam, brine and other lines

THE complete line of Badger Expansion Joints will be available for study, analysis, and discussion.

No doubt you have heard of the Badger Joints—of the correctly designed and proportioned corrugations—of the elimination of the necessity of packing—of the equalizing rings for distributing the flexing—of the Monel Metal sleeve for superheated steam line service—of the welding as well as the flanged ends.

No doubt you have heard of these Badger Joint features. Here is your opportunity of seeing them.

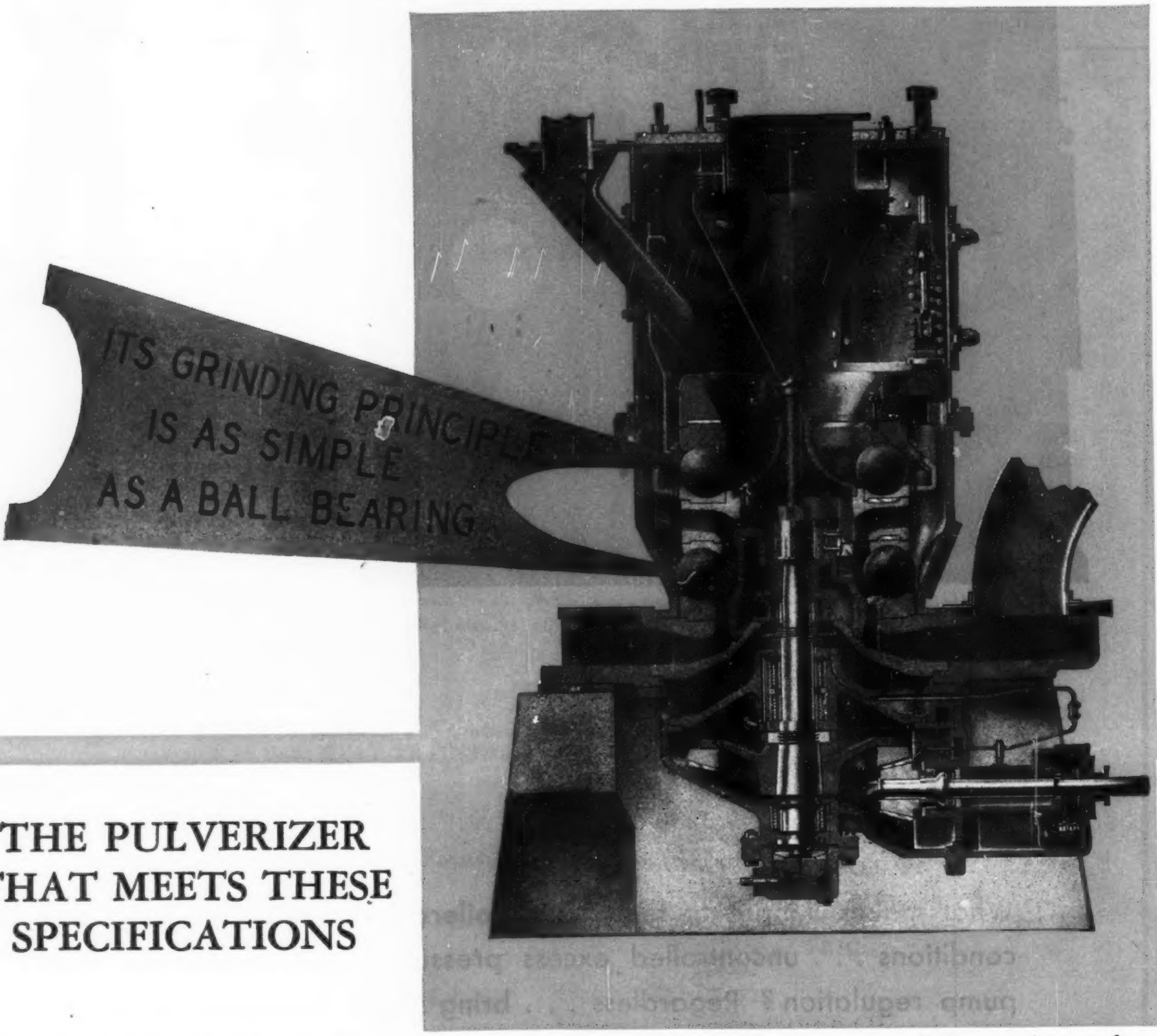
E. B. BADGER & SONS COMPANY

65 Pitts Street, Boston, Mass.

Atlanta, Georgia, Red Rock Bldg.
Charlotte, N. C., 1408 Independence Building
Chicago, Ill., 2831 South Parkway
Cincinnati, Ohio, Union Trust Bldg.
Cleveland, Ohio, Guardian Bldg.
Detroit, Mich., 402 Ford Bldg.
Houston, Tex., 1308 Sec. Nat. Bk. Bldg.
Indianapolis, Ind., 823 Occidental Bldg.
Kansas City, Mo., 1336 Oak Street
Los Angeles, Cal., 517 Hollingsworth Building
Minneapolis, Minn., 732 Build. Exch.
Montreal, Que., Can. Cement Bldg.
New Orleans, La., 419 Maritime Bldg.
New York City, 271 Madison Ave.
Philadelphia, Pa., 1500 Walnut St. Room 901
Pittsburgh, Pa., Union Trust Bldg.
Salt Lake City, Utah, Kearns Bldg.
San Francisco, Cal., Sharon Bldg.
Seattle, Wash., 415 Lenora Street
St. Louis, Mo., 3605 Laclede Ave.

BADGER EXPANSION JOINTS

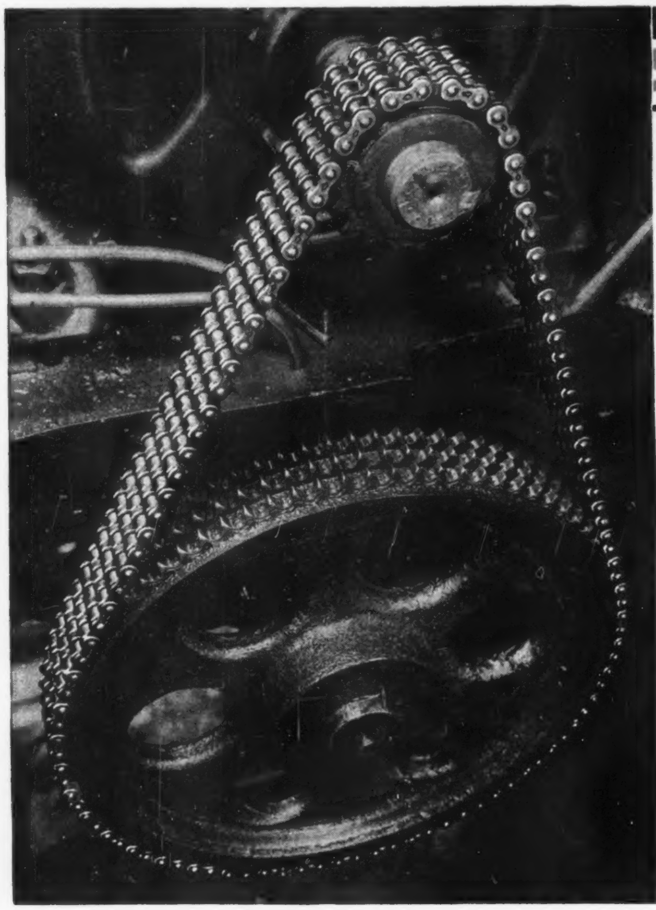
NEWLY DESIGNED MILL
SETS NEW STANDARD OF



THE PULVERIZER THAT MEETS THESE SPECIFICATIONS

1. Small floor space for given output.
2. Constant-speed motor drive.
3. Low power consumption.
4. Power varying with rate of coal feed.
5. No lubrication within grinding zone.
6. Grinding zone sealed from parts requiring lubrication.
7. Smooth running and quiet.
8. Grinding pressure independently applied and not dependent on speed of mill.
9. Wide operating range — full capacity to the minimum permitted by the burners.
10. Respond quickly, but not too quickly, to change in rate of coal feed.
11. No metal-to-metal abrasion of grinding parts.
12. Fineness not affected by wear of grinding parts.
13. Fineness always under control.
14. Pulverize coal of any hardness or grindability.
15. Maintenance exceptionally low.

SEE OUR EXHIBIT AT THE NEW YORK POWER SHOW
BOOTHS 54 AND 55



DIAMOND STOCK Drives *eliminate the delay*——

between your needs and their fulfillment

PUT down three things: *motor speed; reduction ratio; amount of power to be transmitted.*

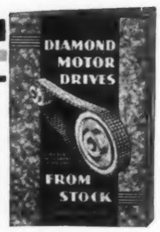
These, with Drive Data Book No. 78, are all you need to select promptly the right Diamond Drive for your installation and also to get it promptly—*from stock.*

Diamond Motor Drives are more than stock drives as that term is commonly understood—they are standard drives, individually engineered and produced in quantities to custom-built requirements of excellence . . . from $1/4$ to 75 horse power . . . from 600 to 1800 r.p.m. driving speeds . . . from 1/1 to 8.4/1 ratios . . . all immediately available.

Lifted from the experience of serving a growing market for nearly half a century, standard Diamond Motor Drives offer advantages found in no other high speed transmission. They are fully described and catalogued in the new book No. 78 . . . mail the coupon for a copy—you will find it a valuable addition to your catalog file.

DIAMOND CHAIN & MFG. CO.
413 Kentucky Avenue Indianapolis, Indiana
Offices and Distributors in all Principal Cities

TRADE MARK



Diamond Chain & Mfg. Co.
413 Kentucky Avenue, Indianapolis, Ind.

Gentlemen:
Please send me a copy of your new *Stock Drive Data Book No. 78*—without obligation.

Name..
Business......................................
Address.......................................
City.............................*State*.............

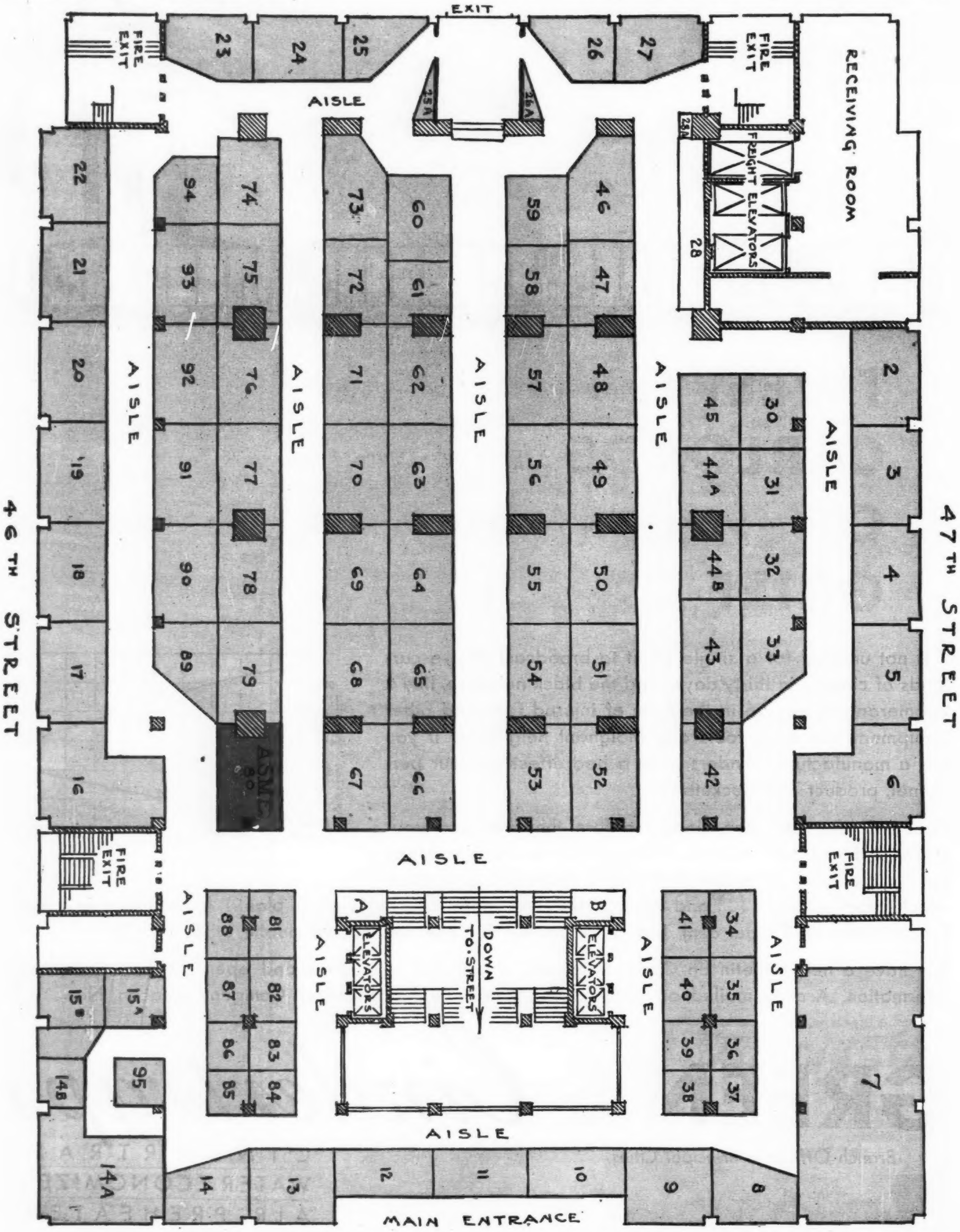
DIAMOND CHAIN
ROLLING ~ AT POINTS OF CONTACT

(A-859)

FIRST FLOOR BOOTHS NO. 1 to 95

Ninth National Exposition of Power and Mechanical Engineering

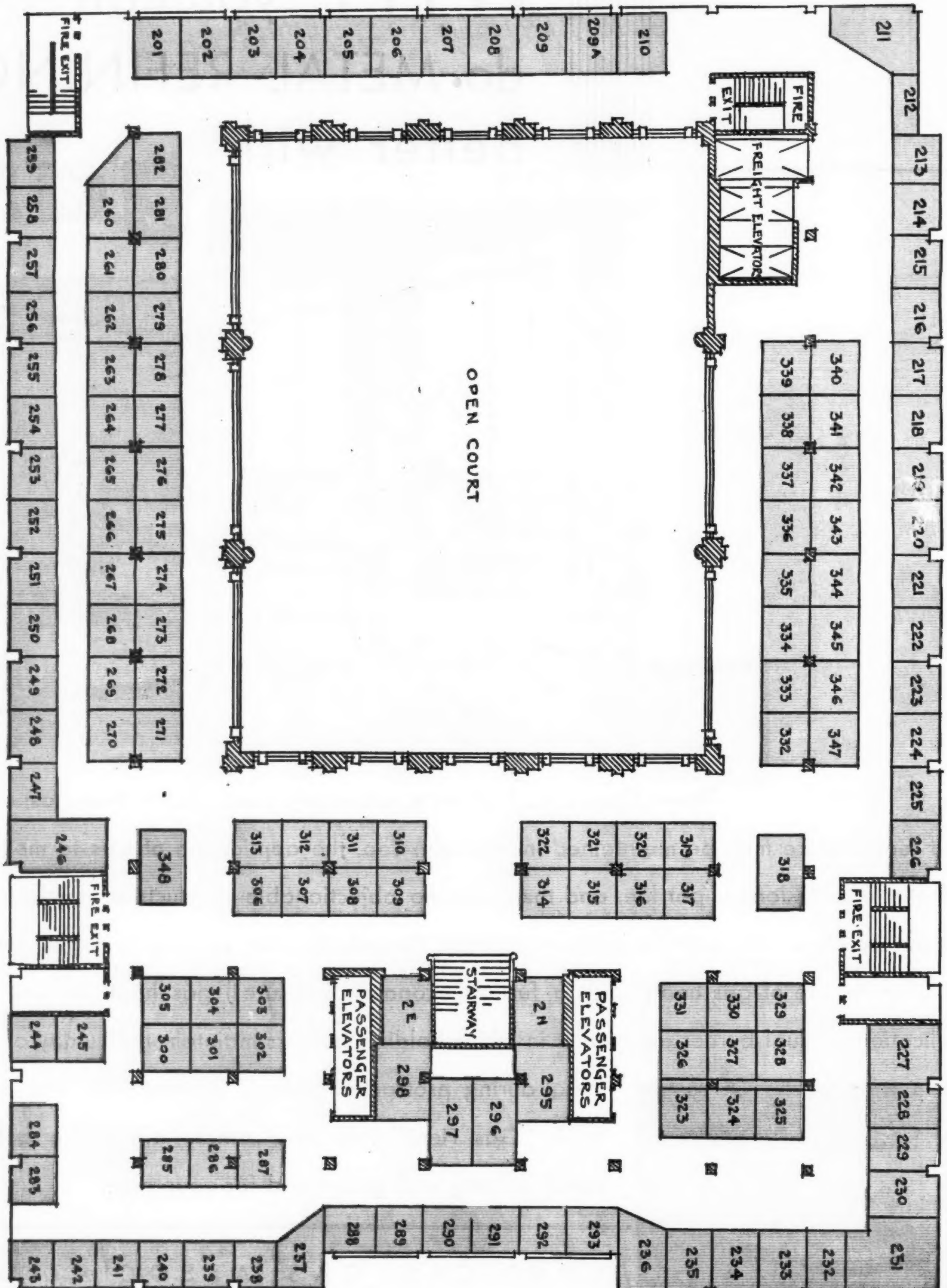
December 1st to 6th, 1930 **Grand Central Palace, New York, N. Y.**



SECOND FLOOR BOOTHS NO. 200 to 348

Ninth National Exposition of Power and Mechanical Engineering

December 1st to 6th, 1930 **Grand Central Palace, New York, N. Y.**

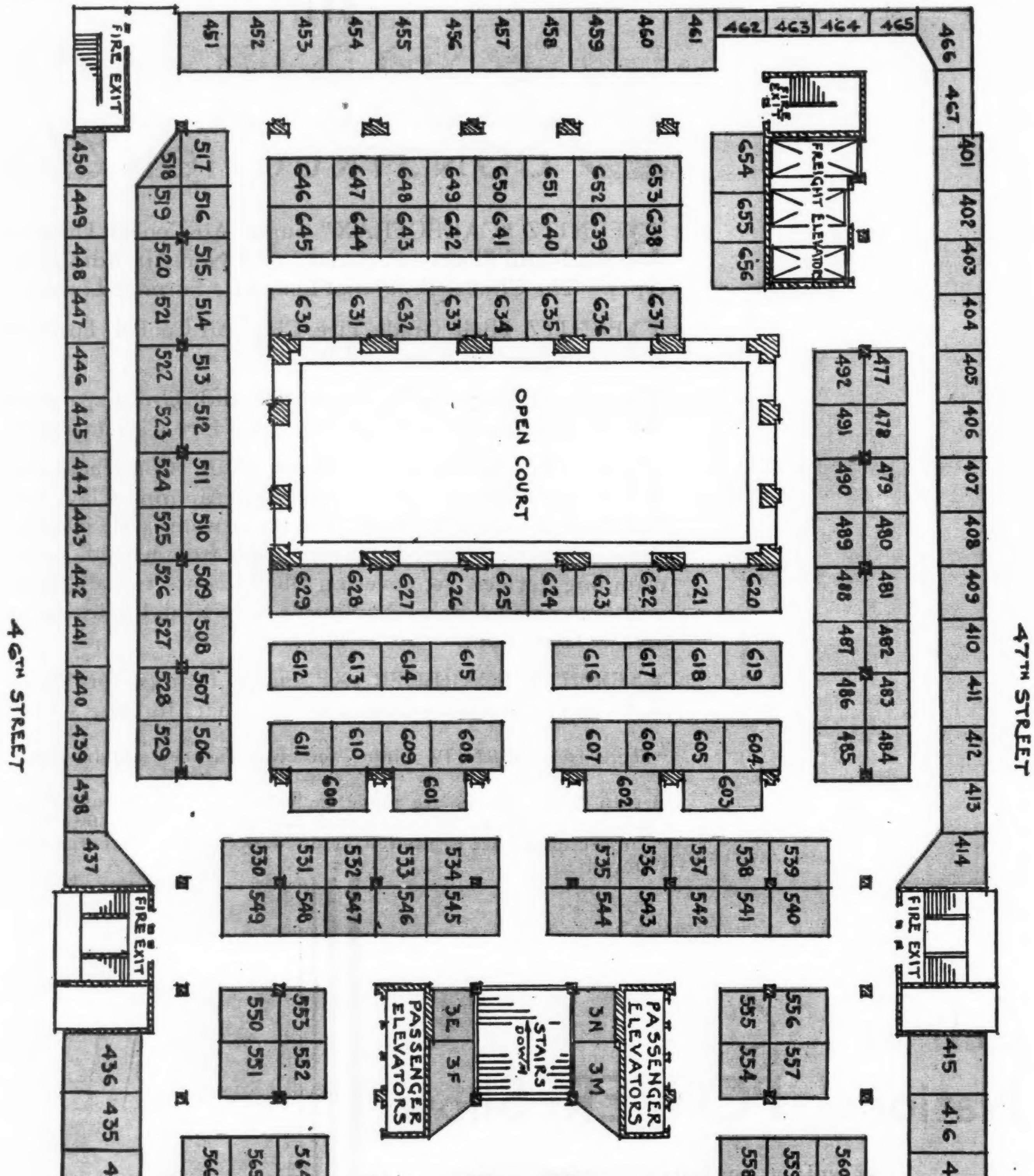


See Pages 74-92 for Directory of Exhibitors *See Page 128 for Alphabetical List of Advertisers in this Section*

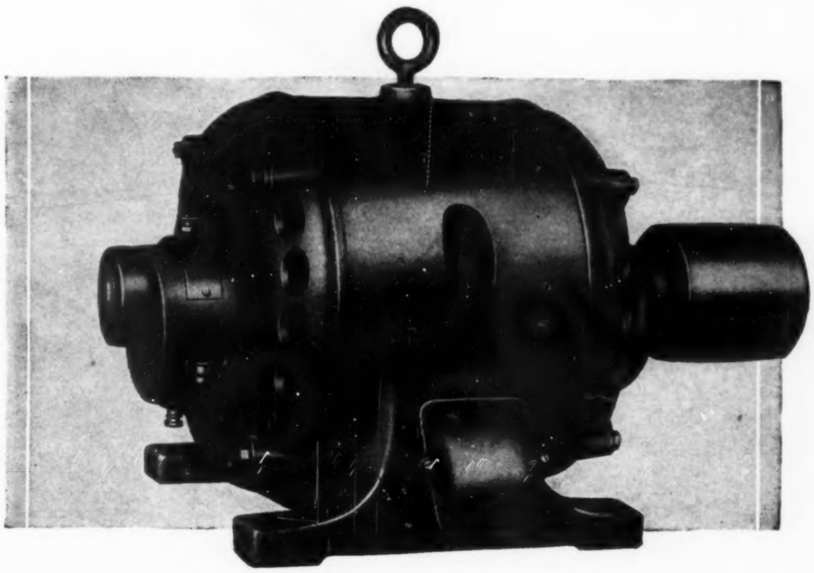
THIRD FLOOR BOOTHS NO. 401 to 656

Ninth National Exposition of Power and Mechanical Engineering

December 1st to 6th, 1930 **Grand Central Palace, New York, N. Y.**



THEY KEEP A-RUNNING



5 Horse Power Century Type SCH Low Starting Current... High Torque Double Squirrel Cage Induction 3 and 2 Phase Motor.

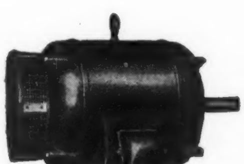
ELIMINATE

Current-Limiting Starting Equipment

Less current is required to start a Century Type SCH Double Squirrel Cage Motor than a corresponding size standard single squirrel cage motor. This permits the use of any approved across-the-line switch or starter and also results in lower installation and maintenance costs . . . The starting current of the 30 horse power and smaller size motors is within NELA starting current rules.

As an added economy . . . a lower-rated Century Type SCH Motor can frequently be used in place of a higher-rated single squirrel cage motor—because the static torque of the Double Squirrel Cage type is substantially greater than that of a standard normal torque single squirrel cage motor of the same rating.

Built in standard sizes from 2 to 100 horse power.



Totally-Enclosed Fan-Cooled Motor. Built in all standard sizes from 1½ to 150 horse power.

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MOTOR GENERATOR SETS, ROTARY CONVERTORS, FANS AND VENTILATORS

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FOR MORE THAN 26 YEARS AT ST. LOUIS

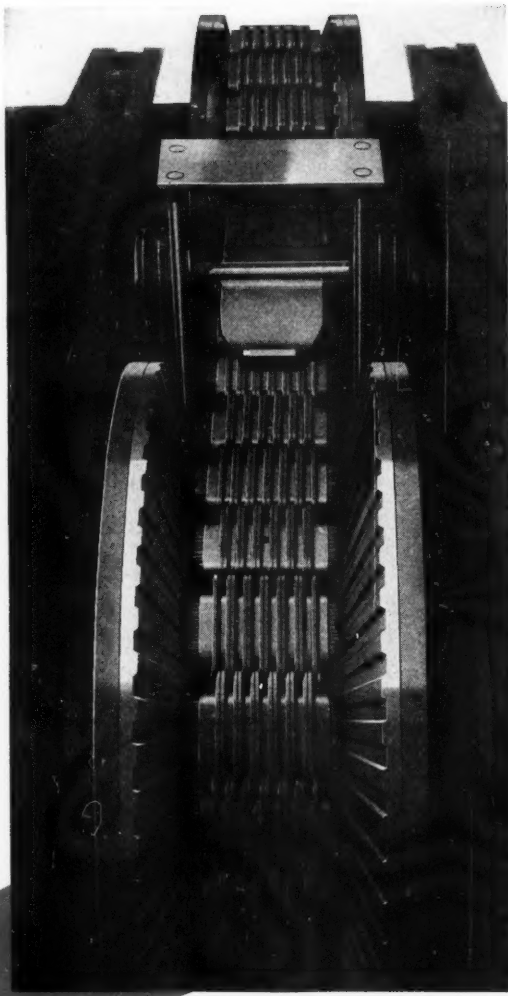
AN INNOVATION IN

AN all metal, chain-driven variable speed transmission providing an infinite variety of positive speeds, without steps, or dependence upon friction . . .

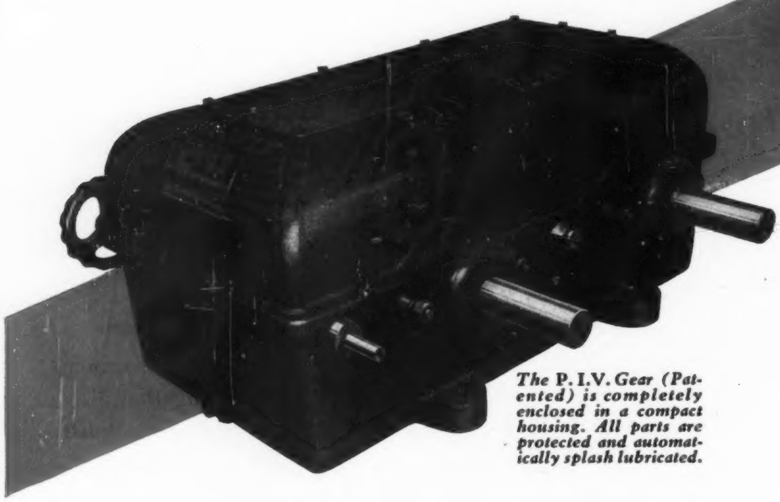
For more than three years Link-Belt has been testing in practical service an entirely new type of variable speed transmission—the P.I.V. Gear. It is now on the market, and becomes a new unit in Link-Belt's comprehensive line of Positive Drives.

The Link-Belt P.I.V. Gear is unique in that it is the first variable speed device in which the power is transmitted from the input to the output shaft through a positive chain drive.

The chain, with its side-projecting teeth composed of packs of steel laminations, positively engages



Tooth formation of the P.I.V. Chain on the minimum diameter of a wheel (a pair of discs).



The P.I.V. Gear (Patented) is completely enclosed in a compact housing. All parts are protected and automatically splash lubricated.

Link-Belt makes a Positive Drive for every class of power transmission service. These drives include:

Silent Chain Drives
Roller Chain Drives
Herringbone Gear Speed Reducers
Herringbone Gears
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Malleable Iron and Steel Chain Drives

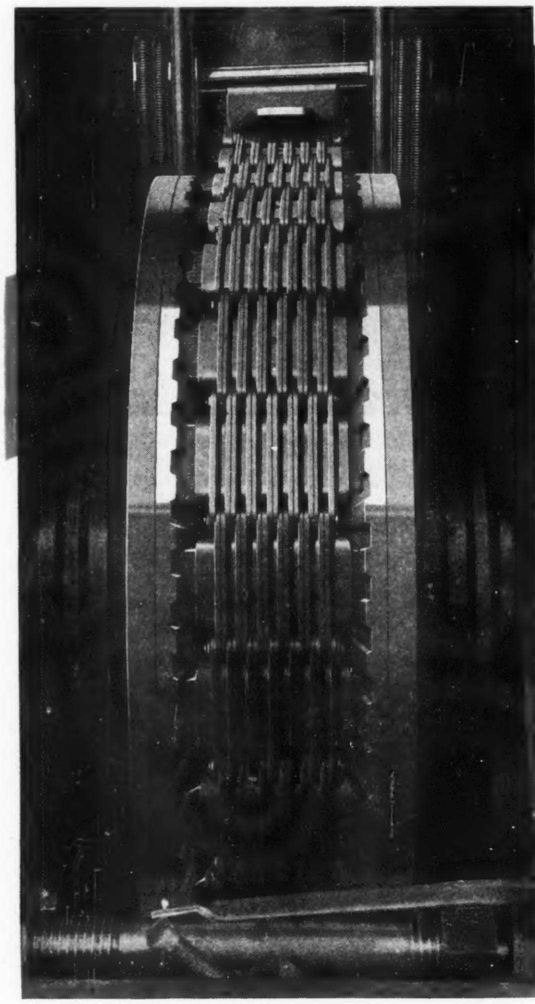
Send for Catalogs

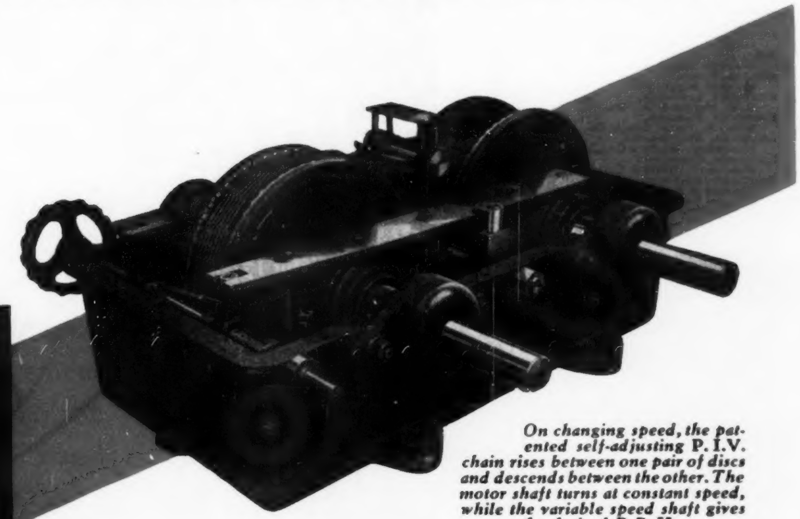
THE LINK-BELT

See the P.I.V. Gear at our Exhibit at the New York Power Show, Dec. 1 to 6, 1930, and the Chicago Power Show, Feb. 10 to 14, 1931

Variable Speed Transmission

Tooth formation of the P.I.V. Chain on the maximum diameter of a wheel (a pair of discs).





On changing speed, the patented self-adjusting P.I.V. chain rises between one pair of discs and descends between the other. The motor shaft turns at constant speed, while the variable speed shaft gives the desired R.P.M.

radial teeth cut into the opposed discs. Thus, while speed ratios may be changed under load, transmission of power through the P.I.V. Gear is always positive.

Link-Belt now builds the P.I.V. Gear in five standard sizes, from 1 to 10 H. P. capacity, providing speed change ratios up to a maximum of 6 to 1.

"Positive Infinitely Variable," the words from which P.I.V. Gear is named, best describe the operation of this drive. The many interesting details of its construction and application are contained in a new Link-Belt book, No. 1274. Ask for it.

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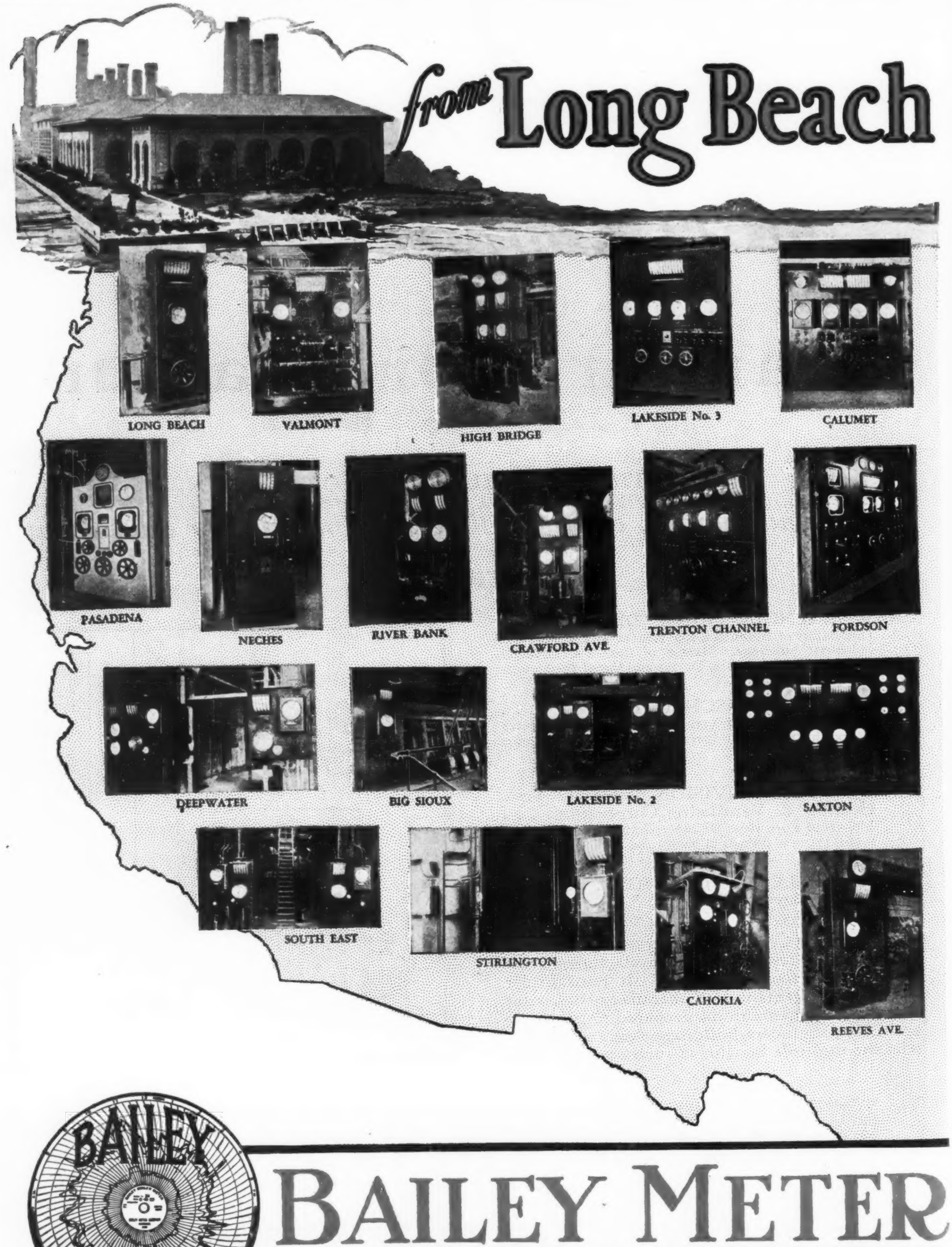
P.I.V. GEAR

POSITIVE INFINITELY VARIABLE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CRAWFORD AVE.
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BIG SIOUX
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SAXTON
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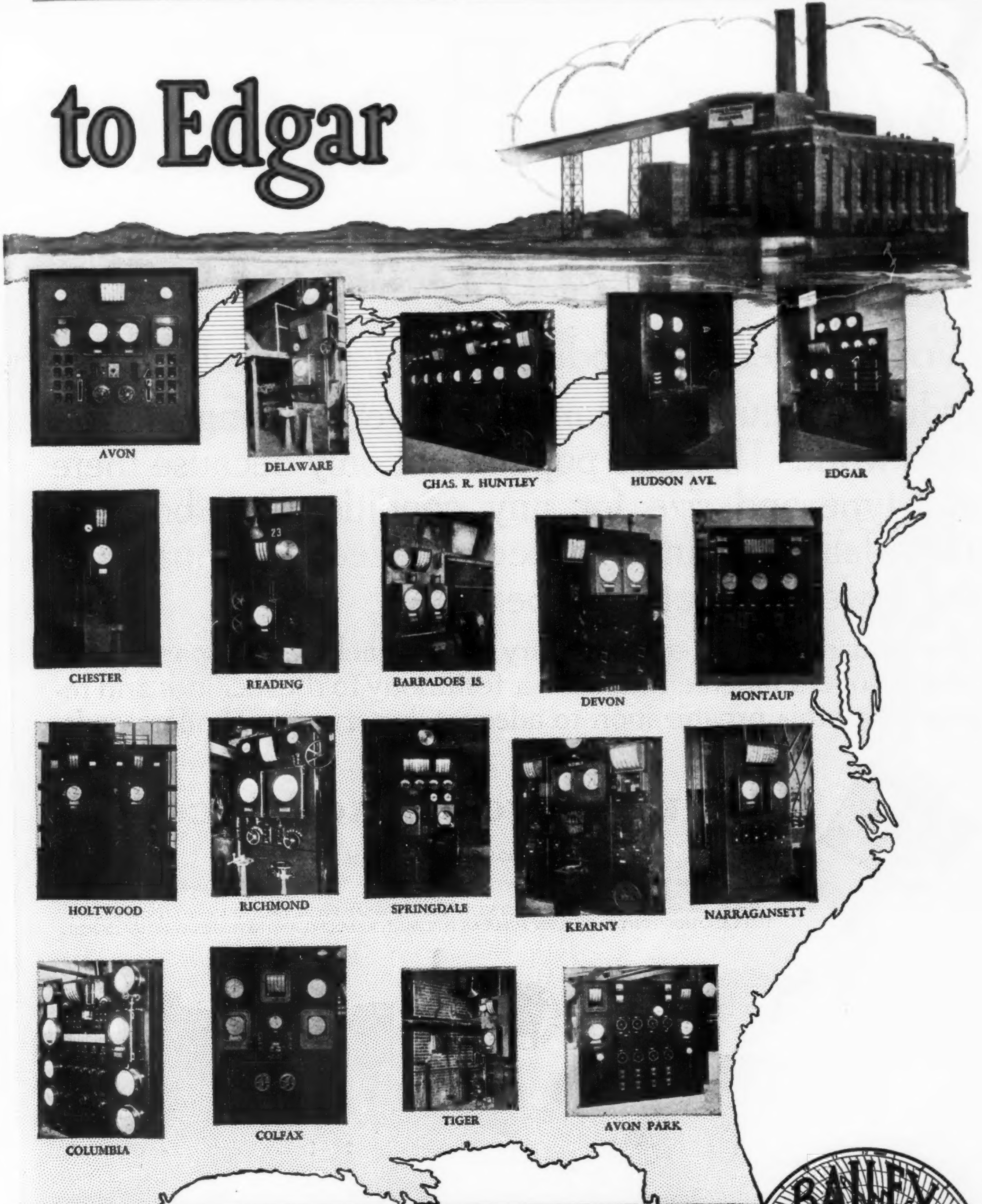
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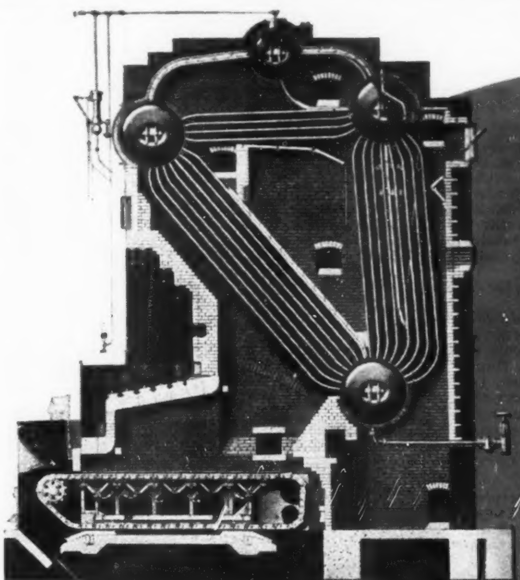
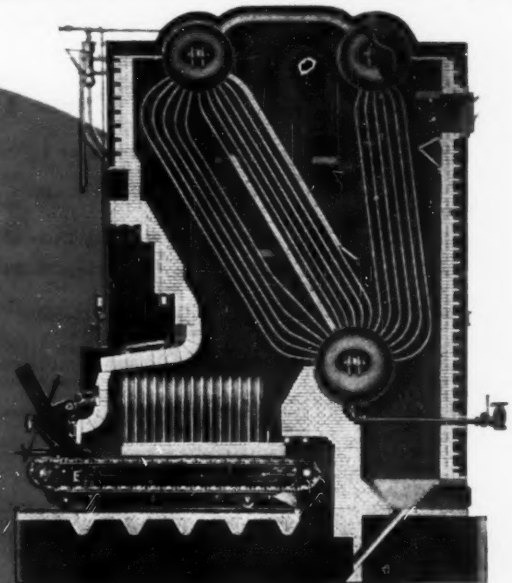
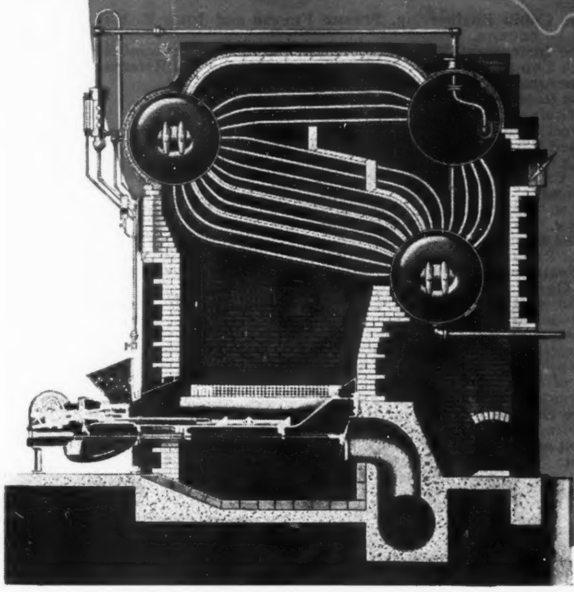
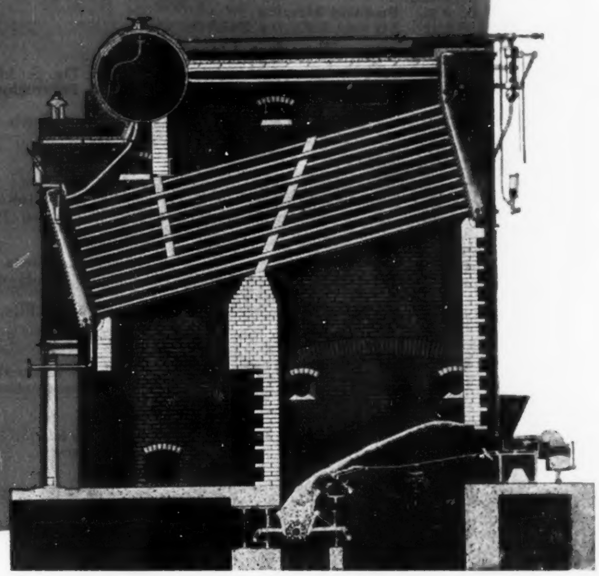








ABMA
The American Boiler Manufacturers Association

A.S.M.E. 1930 Annual Meeting Program

New York, December 1 to 5, 1930

Monday, December 1

9:30 A.M. Council Meeting.
Conference Local Sections' Delegates.
Simultaneous Sessions on

Applied Mechanics (I)
Determination of Stresses in Rotating Disks of Conical Profile, F. C. RUSHING.
Stresses in Retaining and Centering Rings, R. PATTERSON and D. H. HARMS.

Lubrication Engineering
Progress Report of Petroleum Division (*by title*).
Crane Lubrication, EUSTIS H. THOMPSON.
The Work Factor of Lubricating Oil, JAMES G. O'NEILL.
Evaluation of Steam Turbine Oil Stability, CLIFFORD M. LARSON.

12:30 P.M. Luncheon of Council and Local Sections' Delegates.
2:00 P.M. Council Meeting.
Conference Local Sections' Delegates.
Simultaneous Sessions on

Applied Mechanics (II)
Plastic Torsion, A. NADAI.
Vibrations of Railway Bridges, J. N. GOODIER.

Materials Handling (I)
Handling Materials at the Postum Company, Inc., P. P. PRATT.
Materials Handling in the Shoe Industry, KENNETH D. HAMILTON.
Materials Handling Methods in The Fisk Tire Plant, CHAS. EDGAR MAYNARD.

Symposium on Industrial Accident Prevention
Economic Aspects of Industrial Casualty Reductions, L. W. WALLACE.
Engineering Revision—An Essential Factor in Accident Prevention, L. W. CHANEY.
Management's Responsibility for Industrial Accidents, L. P. ALFORD.

8:00 P.M. Business Meeting.
8:30 P.M. Art and Industry Exhibit.

Tuesday, December 2

8:50 A.M. Lecture on Talking with an Audience, DR. S. MARION TUCKER, Head, Dept. English, The Polytechnic Institute, Brooklyn, N. Y.
9:30 A.M. Conference Local Sections' Delegates, with group meetings.
Simultaneous Sessions on

Hydraulics
Progress Report of Hydraulic Division, BYRON E. WHITE.
Federal Relations to Water Power Development, F. E. BONNER.
A Method for Standardization of Centrifugal Pumps, JOS. S. STEPANOV.

Machine-Shop Practice (I)
Survey of Surface Quality Standards and Tolerance Costs Based on 1929–1930 Precision-Grinding Practice, R. E. W. HARRISON and Appendix by C. B. SAWYER.
Transmission of Torque by Means of Press and Shrink Fits, J. W. BAUGHER, JR.

Railroad (I)
Progress Report of Railroad Division.
High-Pressure and High-Temperature Steam, C. F. HIRSHFELD.
The Stug System of Pulverized Fuel Firing on Locomotives, R. ROOSEN.

Materials Handling (II)
Progress Report of Materials Handling Division (*by title*).
Materials Handling in Warehouses, N. E. WHITTEMORE.

2:00 P.M. Conference Local Sections' Delegates.
Simultaneous Sessions on

Machine-Shop Practice (II)
Uses of 16-MM Movies in Industry, MAYNARD L. SANDELL.
Application of Spectroscopic Apparatus to Industry, CHARLES C. NITCHIE.

Industrial Power
Engineering Aspects of Interchange of Power with Industrial Plants, B. F. WOOD.
Combined Heat and Power Supply in Industrial Plants, W. F. RYAN (both represented from World Power Conference).

Railroad (II)
Research Relating to the Action of 4-Wheel Freight Car Trucks, T. H. SYMINGTON.

Materials Handling (III)
For manufacturers of materials handling equipment. Presentation of report and prospectus of committee. Discussion of proposed program of activities.

8:30 P.M. President's Night.
Award of Honorary Membership to Elihu Thomson.
Discussion on Economics by Ralph E. Flanders and Wesley C. Mitchell.
Reception and Dance.

Wednesday, December 3

8:50 A.M. Lecture on Talking with an Audience, DR. S. MARION TUCKER, Head, Dept. English, The Polytechnic Institute, Brooklyn, N. Y.
9:30 A.M. Simultaneous Sessions on

Stabilization of Employment in Industry
Discussion to be lead by EDWIN S. SMITH.

Textile
Progress Report of Textile Division.
Special Applications of Electric Motors in Cloth-Finishing Plants, A. M. MCCUTCHEON.
Lubrication of Textile Machinery, L. A. BAUDOIN.

Fuels
Progress Report of Fuels Division, T. A. MANGELSDORF.
Heat Absorption in Water-Cooled Furnaces, WM. L. DEBAUFRE.
Radiant Heat Transmission Between Surfaces Separated by Non-Absorbing Media, H. C. HOTTEL.

General
Machining Properties of Some Cold-Drawn Steels, O. W. BOSTON.
Frictional Resistance and Flexibility of Seamless Tube Fittings in Pipe Welding, SABIN CROCKER and A. MCCUTCHAN.

12:15 P.M. Luncheon Council and Student Branches.
2:00 P.M. Conference Student Branches.
2:00 P.M. Simultaneous Sessions on

Apprentice Training
Apprentice Training in Virginia, C. F. BAILEY.
Apprentice Training Movement in Wisconsin Industry, HAROLD S. FALK.
Opportunities for Aviation Training, JOSEPH S. MARRIOTT.

Steam Tables

Safety and Wood Industries
(Joint Session with A.S.S.E.)
Dust Explosions with Special Reference to Woodworking Industries, H. R. BROWN.
Wood Research, JAMES W. LAWRIE.
Progress Report of Wood Industries Division, THOMAS D. PERRY.

6:30 P.M. Annual Dinner to New Members. Address on Engineering Encounters Human Nature, by ELLIOTT DUNLAP SMITH, Professor of Industrial Engineering, Yale University, New Haven.

Thursday, December 4

8:50 A.M. Lecture on Talking with an Audience, DR. S. MARION TUCKER, Head, Dept. English, The Polytechnic Institute, Brooklyn, N. Y.
9:30 A.M. Simultaneous Sessions on

Management
American Management in Europe, WALLACE CLARK.
Progress Report of Management Division.

Central Station Power
Operating Experiences, Deepwater Station, K. M. IRWIN.
Operation of the Holland Station, E. M. GILBERT.

Aeronautics
Airplane Cabin Engineering, PIERRE FREYSS and JOHN F. HARDECKER.
Airplane Instrument Vibration, Report of A.S.M.E. Special Research Committee on Airplane Vibration with Special Reference to Instruments.
Progress Report of Aeronautic Division.

Cutting Metals
Tool Steel Tools, A. H. D'ARCAMBAL.
Cemented Tungsten Carbide as Applied to Cutting Tools, L. J. ST. CLAIR.
Stellite Cutting Tools, E. A. BECKER, E. E. GORDON and W. A. WISSLER.

12:30 P.M. Luncheon, Honorary Chairmen of Student Branches.
2:00 P.M. Simultaneous Sessions on

Oil and Gas Power
Progress Report of Oil and Gas Power Division, M. J. REED.
Some Features of the Long-Distance Transportation of Natural Gas, GEO. I. RHODES and EDGAR G. HILL.
A Simple Method for the Calculation of Natural Frequencies of Torsional Oscillation, FREDERIC P. PORTER.

Boiler Furnace Refractories
Comparative Resistance of Refractories to Coal-Ash Slags, R. K. HURSH.
Action of Slags on Firebrick and Boiler Furnace Settings, T. A. KLINEFELTER and E. P. REXFORD.
Furnace Gas Compositions and Temperatures in Underfeed Stoker-Fired Boiler and Their Effect on Boiler Settings, ALBERT C. PASINI and EDWARD M. SARRAF.

3:00 P.M. Ladies' Tea at Museum of Science and Industry, 220 E. 42nd St.
Evening College Reunions.

Friday, December 5

9:30 A.M. Council Meeting.
Simultaneous Sessions on

Symposium on Flat-Bed Cylinder Presses
Some Problems in Standardization, FRED S. ENGLISH.
Design of the New Harris Automatic Two-Color Flat-Bed Press, ALFRED S. HARRIS.
Report on Progress in Printing, WINFIELD S. HUSON (*by title*).

Lubrication Research
On Problems in the Theory of Fluid-Film Lubrication, with an Experimental Method of Solution, ALBERT KINGSBURY.
Lubrication Research Activities. Fifth Report of A.S.M.E. Special Research Committee on Lubrication.

Properties of Metals
Properties of Non-Ferrous Metals at Elevated Temperatures, C. L. CLARK and A. E. WHITE.
Comparative Physical Properties of Chromium-Nickel, Chromium-Manganese and Manganese Steels, C. L. CLARK and A. E. WHITE

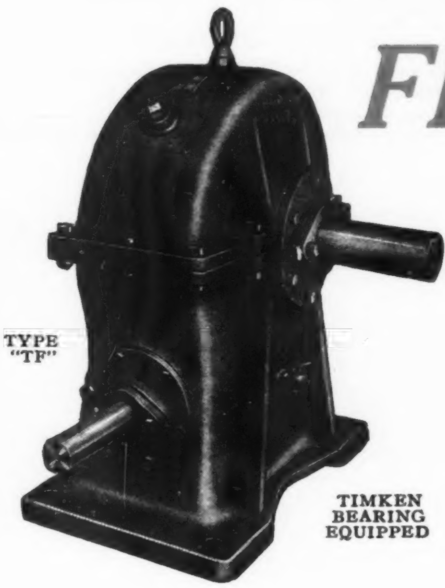
2:00 P.M. Simultaneous Sessions on

Refrigeration
Joint Session with A.S.R.E.
Effect of Humidity on the Heat Transmission of Galvanized Pipe, W. R. WOOLRICH (A.S.R.E.).
Psychometry and the Effects of Air Conditions on Some Familiar Products, DANIEL C. LINDSAY (A.S.M.E.).

Mechanical Springs
Elastic and Inelastic Behavior in Spring Materials. Progress Report No. 7 of A.S.M.E. Special Research Committee on Mechanical Springs, M. F. SAYRE.
Design of a Conical Spring with Coils of a Uniform Slope. Progress Report to the A.S.M.E. Special Research Committee on Mechanical Springs, JOS. B. REYNOLDS and O. B. SCHIER.

Symposium on Flat-Bed Cylinder Presses (Continued)
Five Minutes Talk on Safety. The Relation of Safety to the Printing Industry, ROBT. R. ELBERTY.
Sizes and Tolerances for Metal Fits, C. R. REIMAN.
Design of the Miller Simplex Automatic Two-Revolution Cylinder Press, A. W. BARRETT.
Forces in Connection with the Reciprocating Beds of Flat-Bed Cylinder Printing Presses, B. D. STEVENS and H. E. GOLBER.

STANDARDIZATION PAYS
Reg. U. S. Pat. Off.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340 THOMAS STREET NEWARK, N. J.

ALPHABETICAL LIST of ADVERTISERS in this Section

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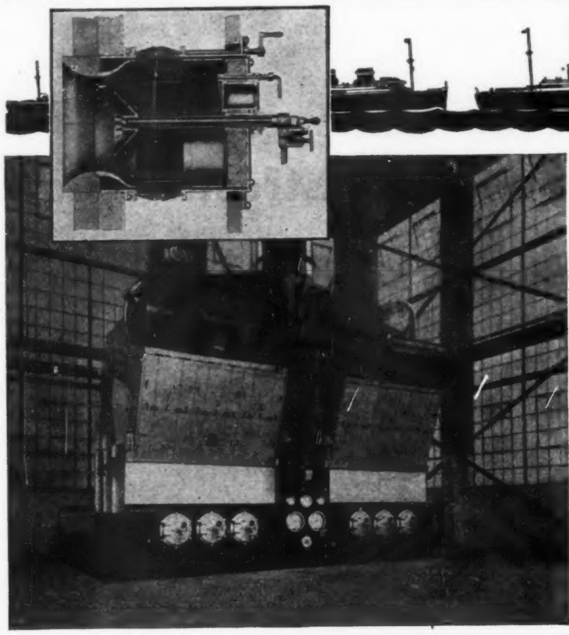
When the "mirror test" is given joints packed with Cranite, a remarkably low percentage of leaks are found, even after long and trying service.



The power plant of the Federal Shipbuilding plant at Kearny, N. J. uses 6 Coen Burners and Registers for their own power plant installation. Above is shown a cut-away view of a type C Coen Register using a Coen Oil Burner.

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Type C Register is suitable for either natural draft or forced draft pre-heated air. It offers the features of safety, accessibility and ease in installation. Complete frontal insulation as well as greater capacity with less air pressure, is provided in the design. In conjunction with the burner the register is designed to give a rotary motion to the air used for combustion without the use of air-directing vanes. The Type C Register can be furnished for use with oil, gas or powdered fuel.

Write us for Bulletins No. 16-C and 20-C, which give full particulars on both burner and register.

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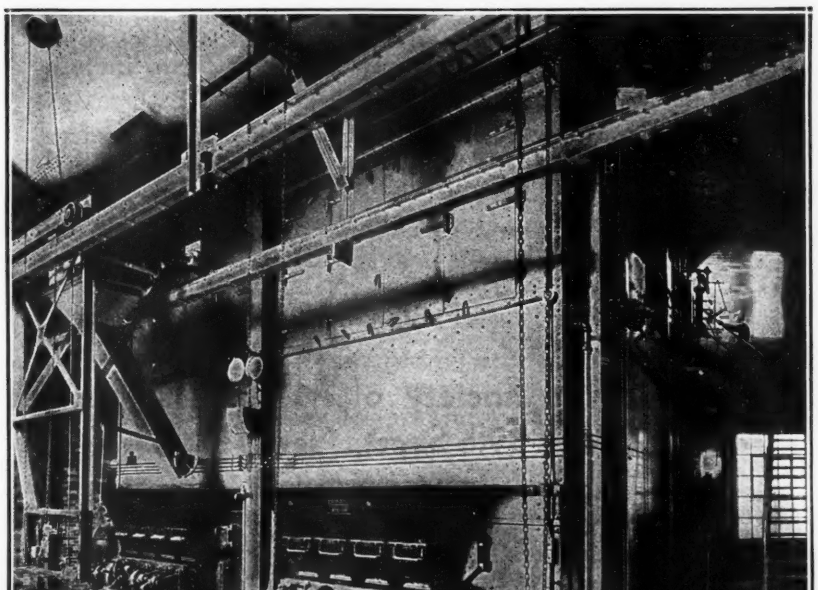
WICKES CROSS DRUM BOILERS



A model laundry with a modern power plant. Unretouched photograph, 2—400 hp. Wickes Cross Drum Boilers. American Laundry Co. (Otte Bros.), Grand Rapids, Michigan. W. W. Bradfield, Consulting Engineer.

The factors of reliability, efficiency, and economy are equally desirable to all users of steam boilers. Competition today demands low unit production costs. In order to obtain this, all mechanical equipment must be highly efficient—combined with a low cost of maintenance and operation.

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NATIONAL METER COMPANY

299 Broadway, New York, N. Y.

Branches in all principal cities

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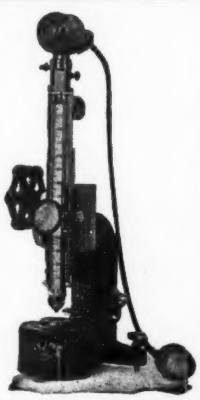
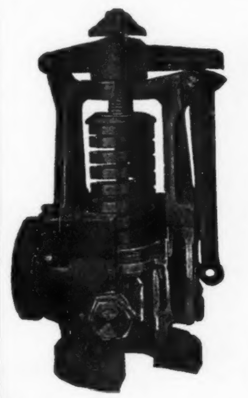


Scleroscope Model C-2



1

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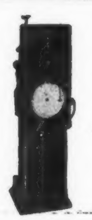
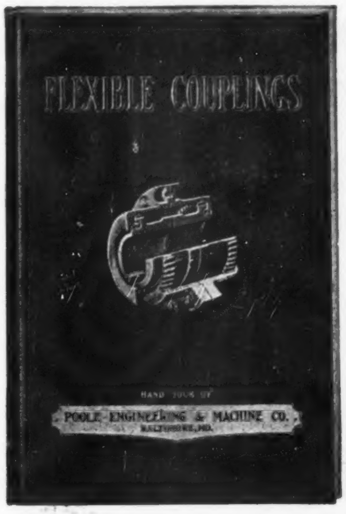


TYPE Y VENTURI METER BULLETIN 233

TYPE GK DIAPHRAGM METER BULLETIN 236

TYPE KS SHUNT METER BULLETIN 234



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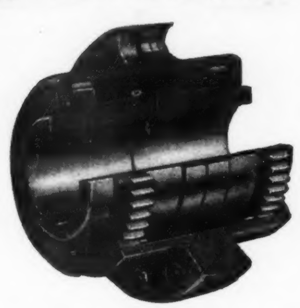
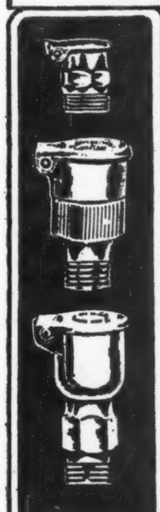
"Flexible Couplings," the Poole Hand Book, has evoked favorable comment from all quarters. And no wonder—it's chock-full of the most valuable kind of information on this subject. Forty pages—each containing a helpful hint or disclosing a new fact. Your request on your letterhead brings it, and there's no obligation.

This is the Poole Flexible Coupling, with a range of features and superiorities that set a new standard in coupling efficiency. Our Hand Book, of course, gives the full details.



Poole Engineering & Machine Co.
Baltimore, Maryland

GITS BROS. Better Oilers

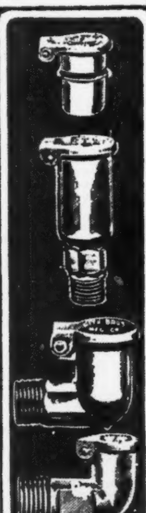


Your oil cup requirements, regardless of quantity, interests us.

Our prices, quality and prompt service, will interest you.

Send for Catalog No. 22

GitsBros.Mfg.Co.
Hawthorne Station Chicago



287 STYLES AND SIZES

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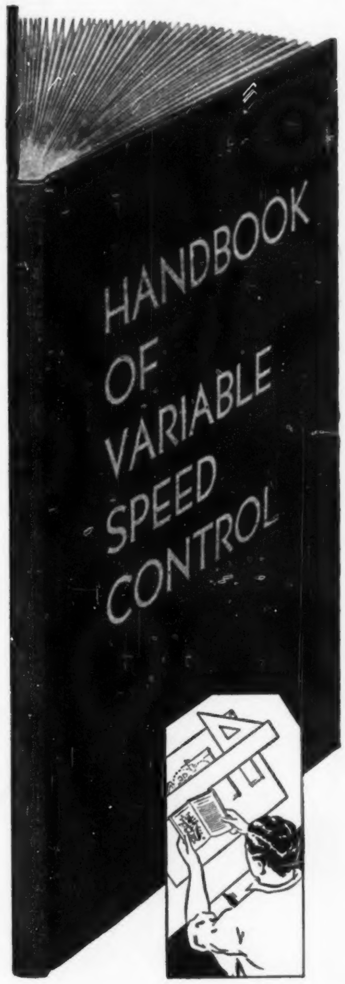
• *This Valuable Book on the Efficient Speed Control of Production Machinery*



Every plant superintendent, every plant owner, every engineer and every machine designer should have a copy of the first edition of this valuable book—a complete and authoritative source of information on the most efficient methods for speed regulation of industrial machinery.

The development of the need for infinite speed regulation . . . the qualifications of speed control equipment . . . the advantages of the REEVES Variable Speed Transmission . . . a list of typical applications in various major industries, naming the machines and plants in which they are in daily use . . . a brief description and illustration of every type of REEVES Transmission . . . convenient charts and tables for the engineer . . . a complete Service Manual covering the installation, operation and maintenance of REEVES Transmissions . . . these and other valuable facts are combined in this convenient, compact, bound book for ready reference.

Regardless of the type of product that you manufacture, this book will be of great interest and value to you. Clip the coupon below and send for your own copy today. If you do not use the coupon, be sure to specify Handbook No. G-12.

This book is being distributed only to those who request it

REEVES PULLEY COMPANY, Columbus, Indiana
Manufacturers of the REEVES *Variable Speed Transmission*

REEVES PULLEY COMPANY, *Columbus, Indiana*

Please send me a free copy of your new Handbook No. G-12.

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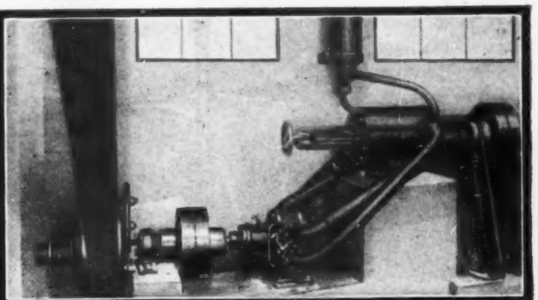
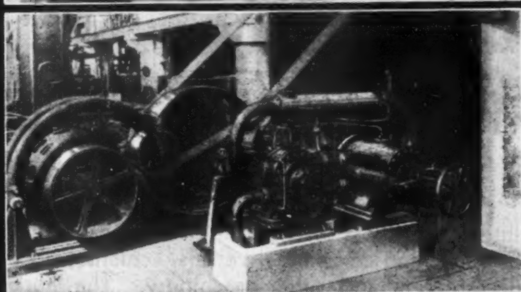
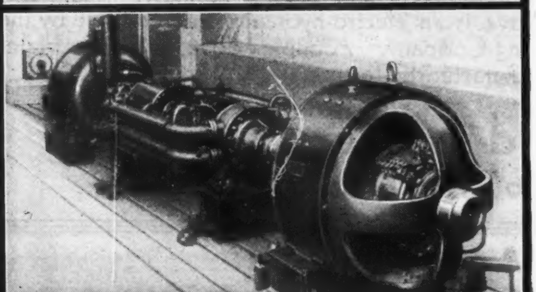
Patent License Available for the manufacture of

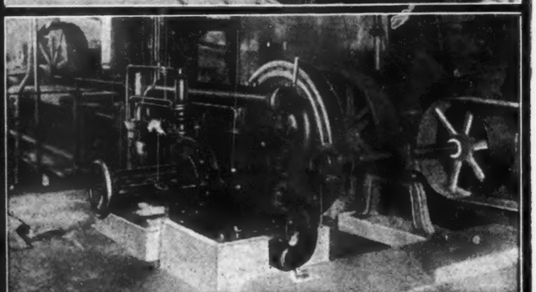
SCHWARTZKOPFF-HUWILER VARIABLE HYDRAULIC GEAR

in United States.









License is available under U.S.A. Patent No. 1688968 for manufacturing the ideal drive for paper-making machines, calenders, etc. in United States.

This gear drive is at present being made by leading manufacturers in Germany and France in sizes from 30 to 300 H.P.

Paper machines and calenders equipped with this drive are being operated in Germany, France, Italy, Norway, Switzerland, and Czechoslovakia.

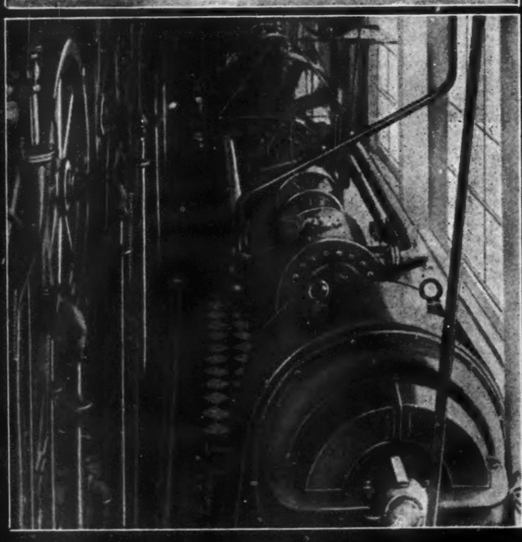
Those securing license may avail themselves of all plans and experience of present manufacturers.

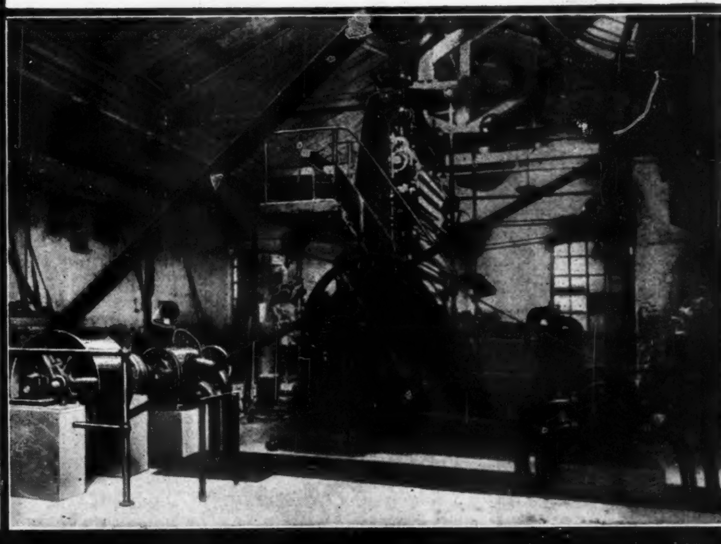
For detailed information apply to

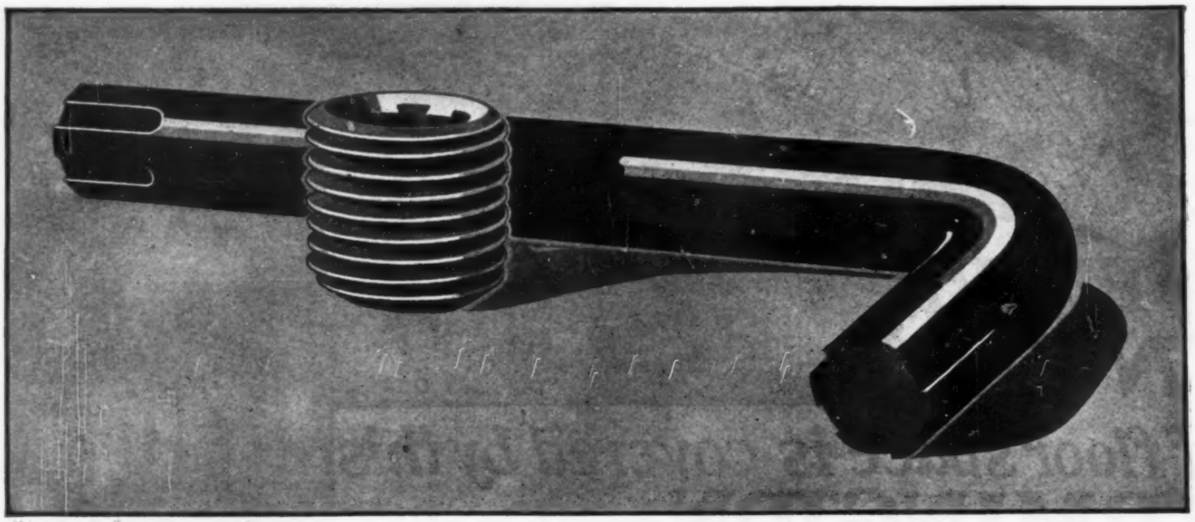
A. HUWILER, Dipl. Ing.

Chaussee Str. 23

Berlin, N.4, Germany.







On Skinner Oil Reclaimers
BRISTO SET SCREWS

THE Skinner Automotive Device Co. have built up their success upon the practical application of economy in operation, and the economical performance of the Skinner Oil reclaimer is written into the records of many users.

Skinner Standardizes on Bristo Safety Set Screws

They found that the patented dovetailed flute design of the Bristo socket and wrench resulted in a *perfect grip*, giving a quicker, tighter set than is possible with any other set screw made.

The centripetal force (toward the center) imparted by the perfect grip of wrench in socket, prevents flaring, splitting or "rounding out." No pressure, sufficient to firmly set the screw, will ever break a Bristo. In place of spreading the socket, abnormal pressure tends to *contract* it.

Bristo Safety Set Screws set up solid and *hold* in moving parts, save assembling time, assure a greater measure of service to your customers, improve the appearance of your product, increase its efficiency, and *—cost you no more than ordinary set screws.*

Figures Talk!

These figures prove, conclusively, our contention that Skinner Renewed Oil has a better body and greater stability. In fact, a comparative analysis of Skinner Renewed Oil was made with the highest grade new oil. The results were almost identical, the principal difference being that, at 100 degrees, the viscosity of Skinner Renewed Oil was slightly higher. And, remember—

The cost of reconditioning this high quality oil was only 6½ cents a gallon!

What does motor lubrication cost you? Tell us approximately what you are paying for new oil—your power rate per kilowatt hour—and the number of gallons drained per year.

We'll gladly tell you how much money you can save!

Skinner Automotive Device Co., Inc.
2229 Dubois, Cor. 14th, Detroit, Mich.

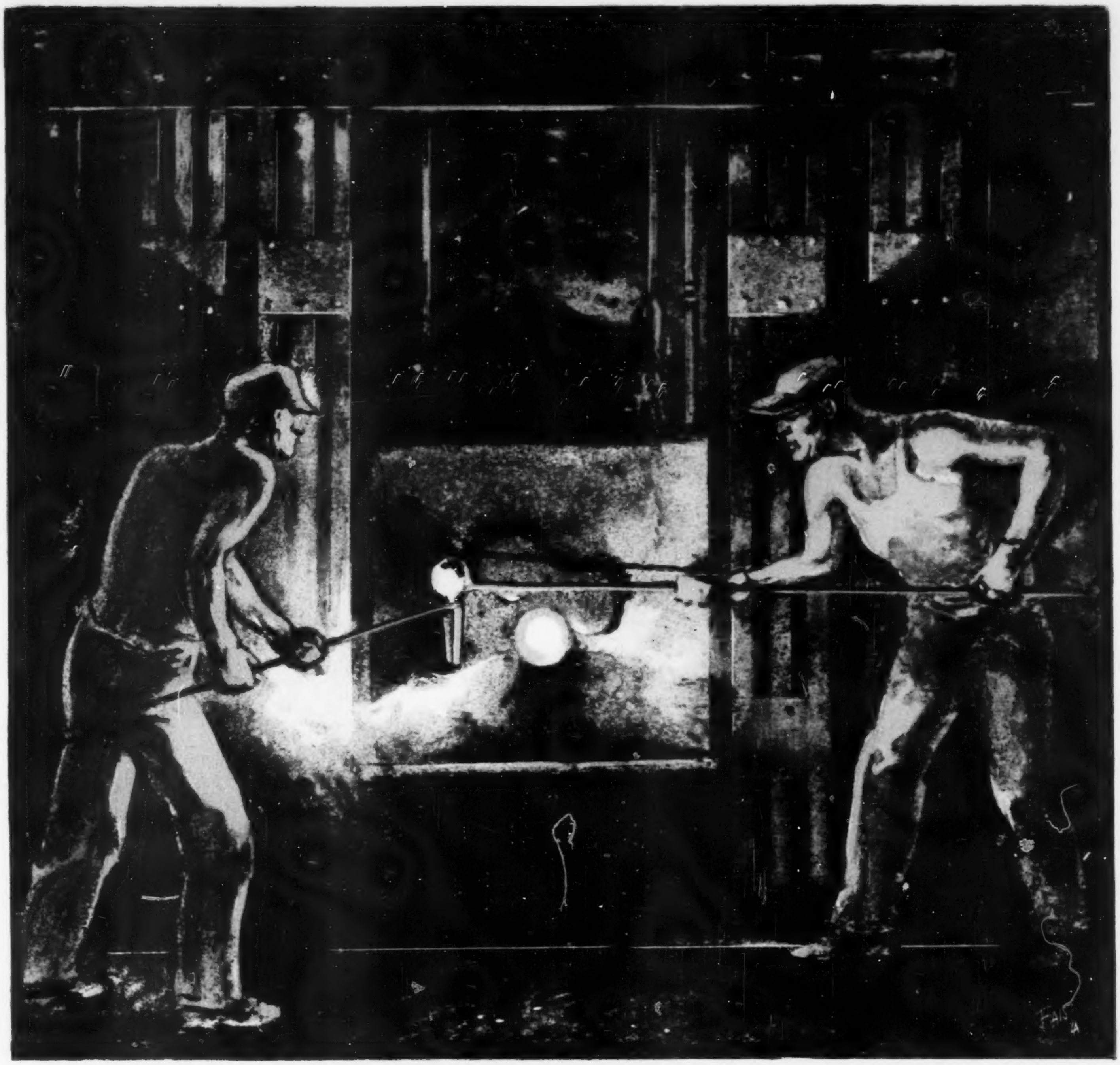
SKINNER OIL RECLAIMER

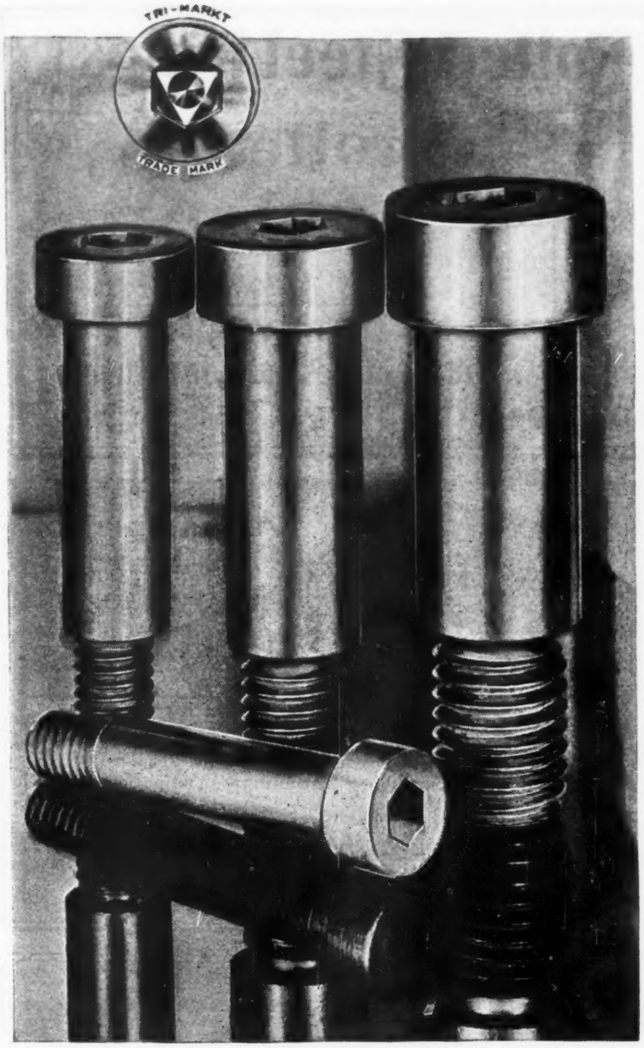
One of a series of business paper advertisements now running on Shinner Oil Reclaimers

We will gladly send you samples of Bristos in the sizes desired. Write Dept. AR.

BRISTO
SAFETY SET SCREWS

THE BRISTOL COMPANY,
WATERBURY, CONN.





ALLEN *Socket Head* Shoulder Screws

in standardized sizes

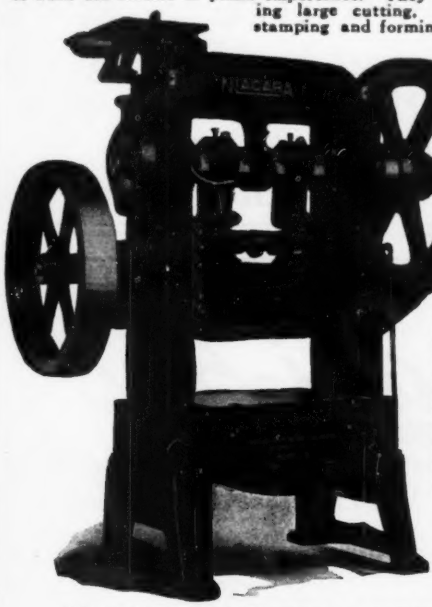
DESIGNERS and Die Makers can now utilize standardized ALLEN Shoulder Screws to replace weak machine screws in their product. All essential sizes in stock—to fit all practical needs in machine design. ★ ★ Tensile strength 175,000-200,000 lbs. per square inch, more than twice the test for machine screws. ★ ★ Why not plan your designs with our Specification Tables before you?

Write for these tables of dimensional data, prices and other particulars.

THE ALLEN MFG. COMPANY
HARTFORD, CONN. U.S.A.

Modern
DOUBLE CRANK PRESSES *by* NIAGARA

TRUE engineering design and construction make these Niagara presses favored where fast production, economy of operation and accuracy of work are factors of prime importance. They are used for operating large cutting, punching, bending, stamping and forming dies.



Write for bulletins on all types of Niagara Presses. Give us the data on your press operations and let Niagara engineers give you the benefit of 50 years' experience in the application of presses to production work.

NIAGARA MACHINE & TOOL WORKS
637-697 Northland Ave. Buffalo, N. Y.

New York City 50 Church St. — Philadelphia Elverson Bldg. — Pittsburgh Park Bldg.

MEET NEW PRICE LEVELS

By having your sheet metal parts made by skilled mechanics, specially trained to give you parts of exact proportions. We believe we are better equipped to make

SHEET METAL PARTS

neater and at a lower cost than most plants are now doing with their own shop. You are under no obligation when you submit blue print or pencil sketch for prices.

THE BREESE BROS. CO.
Cincinnati, Ohio

MAKERS OF
TOTE BOXES—SHOP BOXES
—PICKLING BASKETS
FABRICATORS OF
STEEL—IRON—BRASS—COPPER
—MONEL METAL
Requiring
Stamping—Forming—Drawing
Blanking—Punching

See Data A.S.M.E. Mechanical Catalog, McRae Hendricks and Thomas Catalogues

November, 1930 MECHANICAL ENGINEERING Vol. 52, No. 11

CARD INDEX

Professional Engineering Service

CLASSIFIED INDEX

Card announcements of the Engineers listed below will be found alphabetically arranged on the following pages

CARD ANNOUNCEMENTS ALPHABETICALLY ARRANGED

See pages 166 and 167 for Classified Index in which Engineers having cards are listed according to their specialties

Cards Continued on Next Page

Representatives—Sales Agencies
Businesses For Sale
Partnership—Capital
Manufacturing Facilities

OPPORTUNITIES

Equipment—Material—Patents
Books, Instruments, etc.
Wanted and For Sale

Classified advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of 60 cents a line; 50 cents a line to members of A.S.M.E. Eight words to the line average. Minimum insertion charge, 5 line basis; maximum 20 lines. No display matter carried. *Copy must be in hand not later than the 6th of the month preceding date of publication.*

ADVERTISING MAN—Graduate engineer, with extensive experience and real ability, will create sales producing technical catalogs, circulars and advertisements very reasonably. Part or temporary full-time basis. Address EX-810, care of this journal.

SALES ENGINEERING OFFICE, New York City, equipped to sell, install and service machinery of all kinds. Will handle line independently or as branch office under manufacturer's name. Address EX-811, care of this journal.

FOR SALE—At Niagara Falls, small machine shop, fully equipped two story brick building, approximately 23,500 square feet floor space, located near Railroad and next to City Yard. Owner retiring. Good opportunity. Address EX-812, care of this journal.

SALES ENGINEERING OFFICE located in Philadelphia. Widely known on Eastern Seaboard amongst oil companies and allied industries. President is Member A.S.M.E. Established ten years. Seek sales representation for manufacturers of articles of exceptional merit, well advertised. Particularly interested in lubricating devices, oil handling equipment and oil products marketing equipment. Address M. E. L. at 1110 Otis Bldg., Philadelphia.

WANTED USED HIGH PRESSURE PUMP for two inch pipe. Pump 2000 feet. Arthur V. Ley, 912 Grant Place, N. W. Washington, D. C.

WANTED—correspondence with engineers having practical ideas concerning, and experience with, power house auxiliaries. Address EX-809, care of this journal.

SALES REPRESENTATIVE WANTED—We have some desirable territories available for Sales Engineering Organizations who have entree to Architects, Mechanical Engineers Contractors and Large Industrial Organizations. Address EX-805, care of this journal.

SALES ENGINEER, Member A.S.M.E., 15 years' experience, power plant equipment, established N. Y. office would like to represent responsible Western manufacturer in Metropolitan area. Address EX-808, care of this journal.

EXPLOITATION OF INVENTIONS, Mechanical Engineer associated. Inventions developed. Address Dr. Alfred Muller, Registered U. S. Patent Attorney, 52 Vanderbilt Avenue, New York, N. Y. (Associated A.S.M.E.)

INVENTIONS PATENTED, financed, developed, placed and manufactured. Literature free. Blair Tool & Machine Corp'n, College Point, New York, N. Y. Patent department at Patent Law offices of Edward Gottlieb, 5 Beekman Street, New York, N. Y.

NEW YORK CITY REPRESENTATION—The Sales Agent of the Coppus Engineering Corporation (formerly their Sales, Export and Advertising Manager) wishes to handle additional account. G. H. Bolle, 120 Liberty Street, Room 505, New York, N. Y.

WHAT DO YOU OFFER for a complete set of A.S.M.E. TRANSACTIONS bound in half-morocco from 1880 to 1926 inclusive—48 volumes in all. Owner is anxious to dispose of these quickly and will consider any fair offer. Address EX-789, care of this journal.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th St. New York, N. Y.

Local Sections are established and conduct professional civic and social activities in the following 70 centers

Akron
Anthracite—Lehigh Valley
Atlanta
Baltimore
Birmingham
Boston
Bridgeport
Buffalo
Central Pennsylvania
Charlotte
Chattanooga
Chicago
Cincinnati
Cleveland
Colorado
Columbus
Dayton
Detroit
Erie
Florida
Green Mountain
Greenville
Hartford
Houston
Indianapolis
Inland Empire
Kansas City
Knoxville
Los Angeles
Louisville
Memphis
Meriden
Metropolitan
Mid Continent
Milwaukee
Minneapolis
Nebraska
New Britain
New Haven
New Orleans
North Texas
Ontario
Oregon
Peninsula
Philadelphia
Pittsburgh
Plainfield
Providence
Raleigh
Rochester
Rock River Valley
St. Louis
St. Paul
San Francisco
Savannah
Schenectady
Susquehanna
Syracuse
Toledo
Tri-Cities
Utah
Utica
Virginia
Washington, D. C.
Waterbury
West Virginia
Western Massachusetts
Western Washington
Worchester
Youngstown

Reports of the activities of these Sections appear currently in the A.S.M.E. News

MAKE A CHRISTMAS GIFT TO ALL HUMANITY

This little reminder booklet, for listing the Christmas cards and gifts you wish to send, will help you in your Christmas shopping. It costs a dollar—and this dollar goes into the fight for the control of cancer. The fight against cancer has been waged by the New York Cancer Committee for four years, and has been the means of saving many valuable lives to the community. Your contribution will be a Christmas gift to all humanity.

NEW YORK CITY CANCER COMMITTEE

OF THE AMERICAN SOCIETY FOR THE CONTROL OF CANCER

34 East 75th Street, New York City · Rhinelander 0435

Alphabetical List of Advertisers

See pages 36-54 for Classified List of Mechanical Equipment

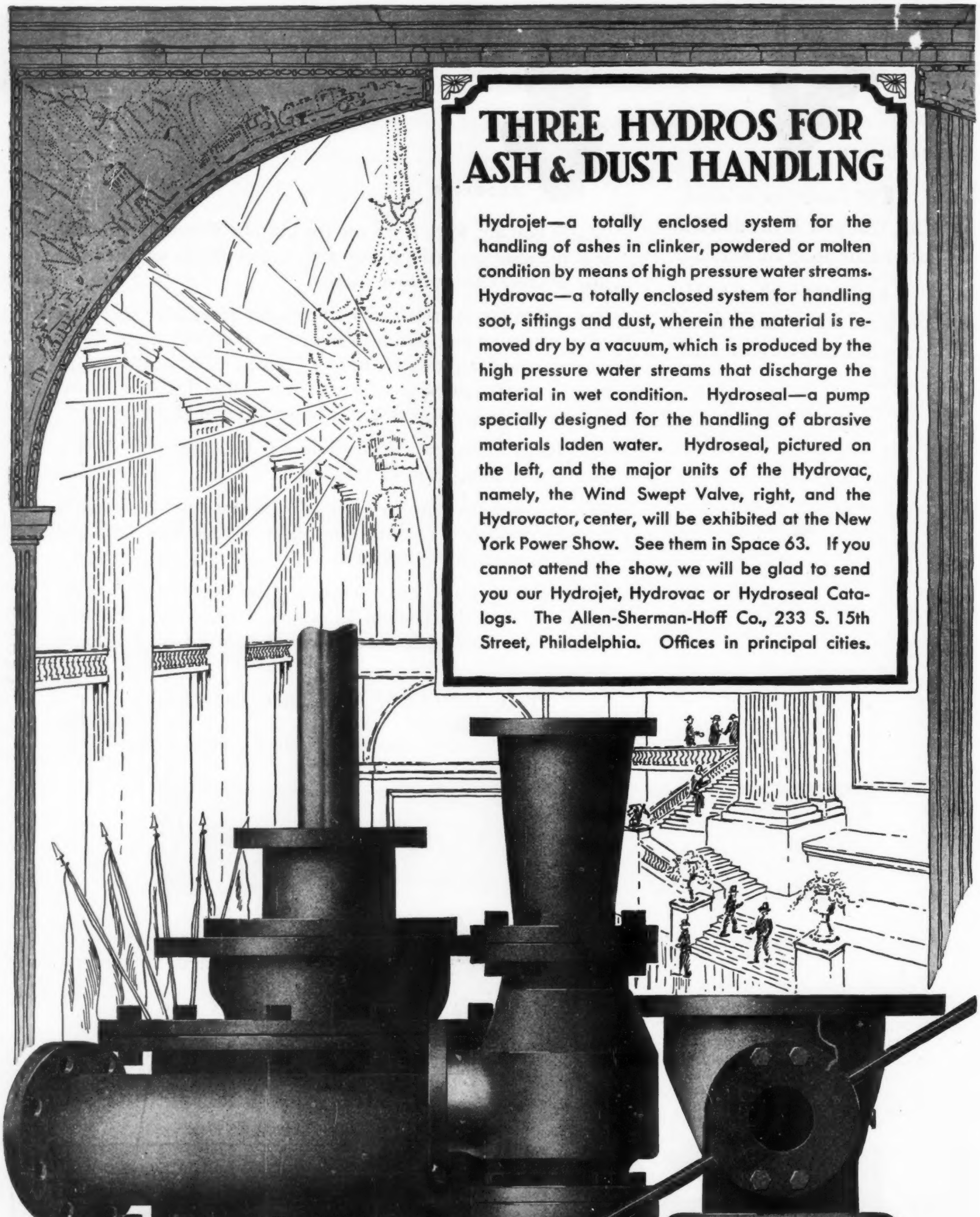
Card Announcements in PROFESSIONAL ENGINEERING SERVICE SECTION will be found on pages 166, 167, 168 and 169

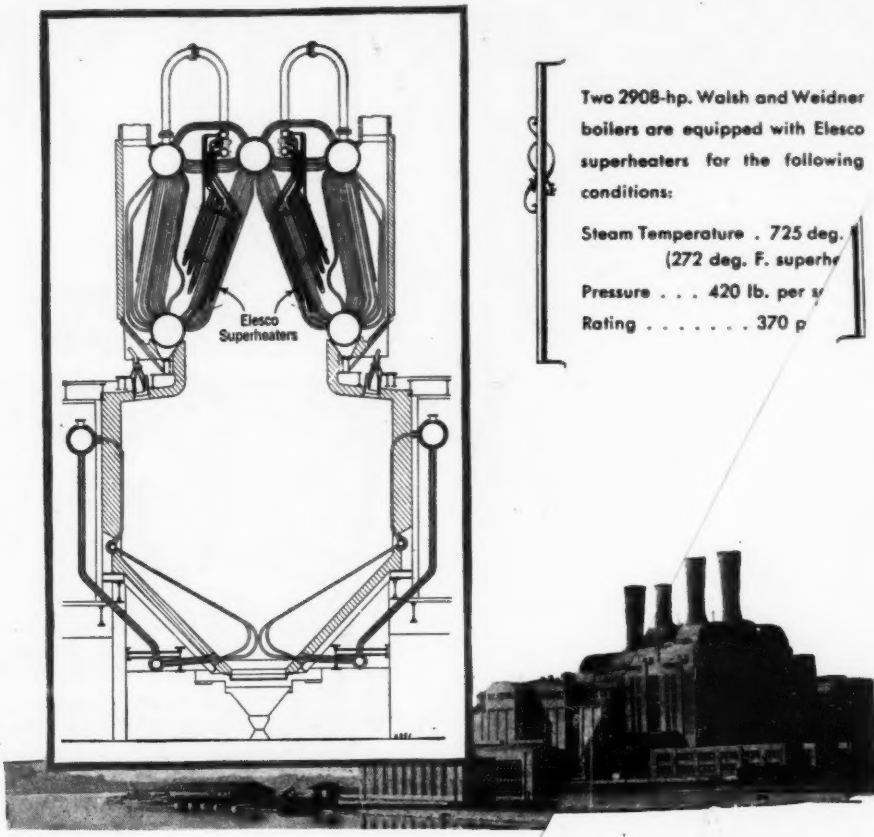
Advertising Forms of MECHANICAL ENGINEERING close on the six of the month preceding date of issue

Space reservations, copy and cuts for advertisements to appear in the Jan. issue should reach us not later than Dec. sixth

IN A.S.M.E. GUIDE TO NATIONAL POWER SHOW SECTION

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1930–31 Edition*


THREE HYDROS FOR ASH & DUST HANDLING
Hydrojet—a totally enclosed system for the handling of ashes in clinker, powdered or molten condition by means of high pressure water streams. Hydrovac—a totally enclosed system for handling soot, siftings and dust, wherein the material is removed dry by a vacuum, which is produced by the high pressure water streams that discharge the material in wet condition. Hydroseal—a pump specially designed for the handling of abrasive materials laden water. Hydroseal, pictured on the left, and the major units of the Hydrovac, namely, the Wind Swept Valve, right, and the Hydrovactor, center, will be exhibited at the New York Power Show. See them in Space 63. If you cannot attend the show, we will be glad to send you our Hydrojet, Hydrovac or Hydroseal Catalogs. The Allen-Sherman-Hoff Co., 233 S. 15th Street, Philadelphia. Offices in principal cities.
HYDROJET HYDROSEAL HYDROVAC



Two 2908-hp. Walsh and Weidner boilers are equipped with Elesco superheaters for the following conditions:

Steam Temperature . 725 deg.
(272 deg. F. superhe
Pressure . . . 420 lb. per s
Rating . . . . 370 p

Trenton Channel Station

Installed an Elesco Superheater in 1928
A Repeat Order Followed in 1929

The Elesco superheater installed at De oit Edison Company's Trenton Channel Station in 1928 is of the r iant and convection type in series for providing high and uniform su rheat over a wide range of ratings. The results obtained were so sa actory that in 1929 a duplicate boiler was equipped with the s ne type Elesco superheater.

The arrangement differs from the usual combination rad nt and convection superheater in that the entire superheating surf e is located directly in the boiler tube banks. Thus, separate radia superheaters in the furnace and long interconnecting pipes are iminated. This arrangement exemplifies the exclusive design flexib ty of the Elesco seamless multiple-loop, single-pass superheater n its economical adaptation to specific requirements.

Foremost industrial plants and central statior are users of Elesco superheaters. Their preference is based on the act that Elesco superheaters, representing the most advanced practi e in superheater design and construction, assure efficient performance with safety and economical maintenance.

THE SUPERHEATER COMPANY

60 East 42nd Street, NEW YORK

Peoples Gas Building
CHICAGO

ELESCO

Union Trust Building
PITTSBURGH

CANADA: The Superheater Company, Limited, Montreal

Represented in

BIRMINGHAM MEMPHIS CHARLOTTE NEW ORLEANS DENVER SAN FRANCISCO HOUSTON KANSAS CITY TACOMA

A-518